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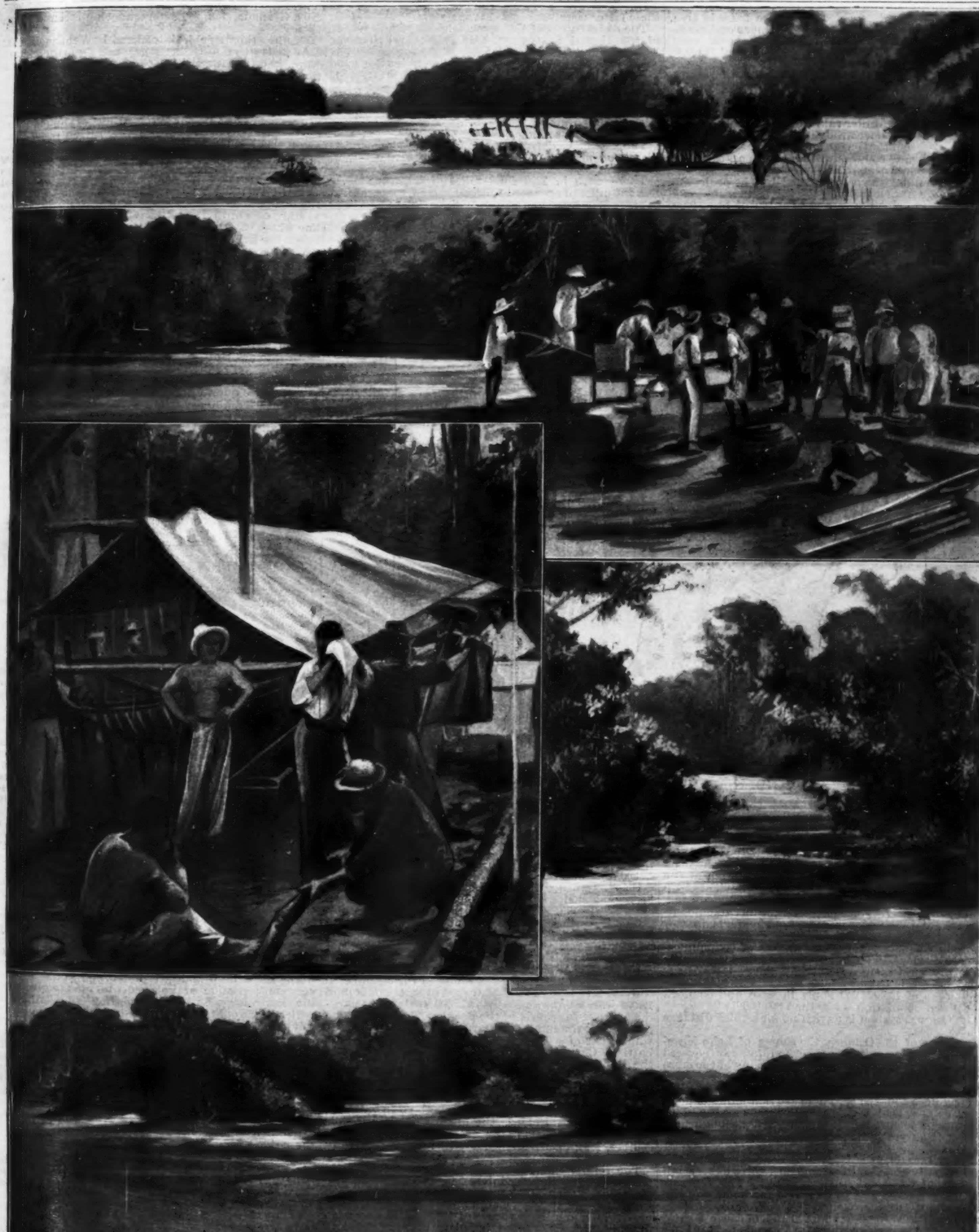

1. View on the Mazaruni. 2. Reloading Boats after making a Portage. 3. Preparing to Camp for the Night. 4. Itabo Caburi Falls. 5. Itakie Rapids.

THE VENEZUELA QUESTION. THE DEBATABLE LAND IN BRITISH GUIANA.—From the Illustrated London News.

VENEZUELA.

In the year 1499 a fleet of three Spanish ships, under the command of Alonzo de Ojeda, sighted the coast of Brazil, and, coasting to the northwest, they entered the large body of water known as the Lake of Maracaibo. On its shores they saw a city of dwellings, built above the water upon piles. Recalling the distant city of Venice, they named this collection of savage huts Little Venice, or, in the native Spanish, Venezuela. The name subsequently came to be applied to the country lying between Lake Maracaibo and the Essequibo, and between the Caribbean Sea and the Valley of the Amazon. This vast region is much of it as yet unexplored, and aggregates some 600,000 square miles in area.

Topographically, the country is capable of a threefold division:

1. The great basin of the Orinoco, a tableland, "diversified by mountain chains," which rise to 8,000 ft. in height, rough and forest grown.

2. The llanos, or plains, 200 000 square miles in area, lying to the west and north of the Orinoco and reaching to the delta.

3. The mountainous northerly regions, which reach from the Colombian frontier to the Caribbean Sea and eastward to the mouths of the Orinoco.

The llanos are a great stretch of prairie land, which, barren of bush or tree, spreads out "as level as the surface of the ocean." It is luxuriant with verdure under the winter rains, but scorched and barren during the summer drought.

These llanos afford a magnificent pasturage for stock, and, before the war of independence, they supported vast herds of cattle.

The highlands, which are formed by the projecting spurs of the Andes, include several fertile and salubrious valleys, which have an elevation of from 2,000 to 5,000 ft. These valleys are the most thickly settled portion of Venezuela.

The river Orinoco, "big water," is well named, for "in breadth, in depth, and in the volume of the flood which it pours into the sea, the Orinoco is one of the giant streams of the world." It can be navigated up to the foothills of the Andes. According to International Trade, to the January number of which journal we are indebted for many of the facts in this present review, the basin of the Orinoco "is highly favored by nature; its natural means of communication are unsurpassed; its spontaneous vegetable products are endless in variety; its mineral wealth is enormous. The Orinoco basin could easily maintain a population of 100,000,000 souls in ease and comfort. The actual population is less than 800,000."

The Orinoco system is navigable for a total distance of 4,500 miles.

The delta of the Orinoco, the shores of Lake Maracaibo, and the lower slopes of the mountains are covered with a dense tropical forest, in which many of the more precious woods abound.

The mineral wealth of the country is vast and "has scarcely been touched." There are rich mines of gold, silver, copper, lead, iron, quicksilver, coal, salt and petroleum. The annual output of gold, although gold mining is as yet in its infancy, already runs into the millions.

Agriculture is in a backward condition; and the area actually under cultivation constitutes but a small fraction of the total cultivable land. The Venezuelans raise manioc and Indian corn for home use, and coffee and cacao for export. Of coffee raised for export the total value is $12 000,000 and of cacao $3,000,000. The annual export of hides amounts to $1,200,000. The total number of head of domestic animals in 1888 was 17,000,000. The climate of Venezuela is marked by the usual tropical division into wet and dry seasons, respectively winter and summer.

The temperature varies with the elevation. It is excessive on the coast, but tempered by the sea breeze. In the valleys of the Highlands of the Andes, above mentioned, the temperature seldom rises above 71° F., and here are located the principal cities, including Caracas, with a population of 72,000; Maracaibo, with 45,000; Valencia, with 39,000; and Barquisimeto, with 31,000. There are fourteen towns with a population of between 10,000 and 15,000, and thirteen towns of between 5,000 and 8,500 inhabitants.

Venezuela is inhabited by a mixed people. Of the descendants of the original tribes, those inhabiting the region to the northwest of the Orinoco are peaceful tillers of the soil; while those who live in the country inclosed by the bend of the river are in a savage state.

The white population is of mixed Spanish and Indian blood. The negro element, once enslaved, is now mixed by intermarriage with the other races. The census of 1891 showed the population to be 2,300,000, of whom 325,000 were aboriginal; 100,000 of these latter were yet in the savage state.

The constitution of Venezuela is modeled after that of the United States. "There is a Federal House of Deputies and a Federal Senate, and each State has also a two-chambered legislature. There is a Supreme Federal Court of Justice and a Supreme Court of Appeal."

Free compulsory education was decreed by the government in 1870, and in 1888 there were 1,979 schools with 100,000 pupils. There is an Academy of Fine Arts, and various schools for technical education.

The post office department handled, in 1888, 3,500,000 pieces of matter. This had increased to 6,000,000 pieces in 1890.

There were in 1893 4,000 miles of telegraph lines and 234 miles of operated railroad. New roads are in course of construction.

The Lake of Maracaibo in the northwest is "a magnificent body of fresh water," with an area of 8,000 square miles; and it is navigable for large vessels. At the entrance is situated the town of Maracaibo, with 45,000 inhabitants.

Puerto Cabello, the next harbor to the eastward, is deep and sheltered, and is the port of the thriving city of Valencia. La Guaira is the port of the capital Caracas, which is 22 miles distant by rail. The mean temperature is 82° F., but as the air is excessively humid, the climate is "intolerable." There is a roadstead, but no harbor proper at Guaira.

In 1810 the Venezuelans rebelled against the Spanish government. During the course of the struggle, in the year 1812, Caracas was destroyed by earthquake, and 12,000 of its inhabitants perished. This calamity temporarily broke the spirit of the people. The slumbering fire broke out again in the form of a guerrilla warfare, which lasted for eleven years. The strife ended at the battle of Carabobo, when Venezuela became a part of the Republic of Colombia. Simon Bolivar, the first President of Venezuela, was the main instrument in securing the independence of the country. The land was devastated for five years—1866–70—by a civil war, the outcome of a struggle between the Liberals and Conservatives. Indeed, the history of the republic has been tumultuous in the extreme, and even in December, 1895, insurrection was still rampant in many districts.

The republic of Venzuela, which a few months ago possessed but little more interest for the American people at large than any other of the South American states, has of late become an absorbing topic of conversation, and a lively source of debate. The occasion for this interest is to be found in the long standing "boundary dispute" between Venezuela and the adjoining British colony of Guiana, which in the declining days of 1895 was brought before the American people in a presidential message. The dispute arose out of an ambiguity in a treaty made in 1691 between Spain and the Dutch, in which it was agreed that the Orinoco colonies should belong to the Spanish, and the Essequibo colonies to the Dutch. At that date the country now in dispute was uninhabited.

The Venezuelans contended that by the term "Essequibo Colonies" it was intended to include only the Dutch settlements which lay to the east of the Essequibo River—the general course of the river being north and south—and they claimed all the country lying to the west of this river as their own.

The British government interpreted the term Essequibo Colonies to cover all the country included in the watershed which drained into this river; and claimed that the Dutch by their official acts in 1759 and 1769 actually held this country and protested against Spanish interference with the Dutch settlers within it. They urge that "this western frontier of British Guiana was accepted without any objection by Spain, while she yet retained the sovereignty of Venezuela, and afterward by the United States of Colombia or New Granada, before the Venezuelan secession from them."

On the other side it is claimed by Venezuela that British settlers have been gradually pushing westward, and that the British claims have been proportionately elastic.

In 1841, by the instruction of the British government, the Schomburgk line was run, but it was strongly opposed by the republic. This line extends beyond the watershed of the Essequibo and touches the mouth of the Orinoco. As the result of Venezuelan opposition, Lord Aberdeen proposed a compromise line. In this line the point at the Orinoco was abandoned, the new starting point being at the mouth of the Macoco River to the eastward. Venezuela met the proposal of Lord Aberdeen half way, being willing to grant a full one-half of this territory. The dispute remained in statu quo until Lord Granville, in 1881, proposed a line whose coast line starting point was half way between the Schomburgk and Aberdeen lines.

With the discovery of the Barima gold fields the settlers pushed out westward, and the camp of the British miner was pitched far beyond the boundary of the Granville line of 1881, though not beyond the country over which, in 1759, the Dutch had claimed jurisdiction.

At the present writing the British government is willing to arbitrate this disputed territory which lies to the west of the Schomburgk line, but refuses to subject to arbitration the territory lying between this line and the Essequibo River, mainly on the ground that it is inhabited by 40,000 British colonial subjects.

The whole question, reaching back, as it does, some two centuries, and involving documentary evidence in different languages, some of it necessarily of great age, is an exceedingly complicated one, and certainly a question upon which no casual student can pronounce an intelligent opinion. The high personal character and great legal ability of the United States commission, and the fact that the British government is placing its full data at the disposal of the committee, make it evident that as soon as they shall report, and only then, will the public at large be in a position to judge intelligently of the true merits of the question.

MAP OF BRITISH GUIANA AND VENEZUELA, SHOWING TERRITORY IN DISPUTE.

BRITISH FEELING ON THE AMERICAN CRISIS.

The calmness with which the British public received the message of the American President, their reluctance to answer it by a simple defiance, and their general refusal to believe it serious, have been so misinterpreted on the Continent that it is worth while to explain their attitude at some length. They had at least three reasons for remaining quiet, one of which was their own profound innocence of intention, bad or good. Most wars have been preceded by a certain amount of bickering, or, at least, of hostility of feeling; but in this case the British people were unaware even of a reason for dispute. They had no more idea of attacking, threatening, or even annoying the United States than of doing the same things to China or Sweden. Probably not ten men in the kingdom, outside the Foreign Office and the foreign division of one or two journals, were aware that there was any question open between the two countries. To the majority of Englishmen Venezuela was only a word which they vaguely recalled as having seen upon a map, and the allegation that they were oppressing Venezuela, or wanted something from Venezuela, came on them with a shock of surprise. They wanted nothing and feared nothing in that part of South America, and Mr. Cleveland's indignation seemed to them so amazing that they interpreted it at first as unreal, simulated, a mere election maneuver.

Even when they perceived its seriousness they were too surprised for anger, and expected to see the annoyance on the other side of the water disappear on a little reflection, and the reception of a disclaimer of any intentional offense. They felt like persons whose words have been misinterpreted, and could not, for very consternation at the accidental offense given, feel the indignation which, according to Continental critics, it would have been honorable to display. "What an unfortunate mistake for President Cleveland to have made," nearly summed up their thoughts, and they waited, fully anticipating some later explanation. Innocence of this kind is so seldom real, especially on the Continent, that we can fully allow for the incredulity of lookers-on, but in this instance it actually existed. Having no purpose in their minds, whether honest or treacherous, grasping or benevolent, Englishmen were puzzled to find a malignant purpose attributed to them, and at first could hardly believe in the seriousness of the menace addressed to them. If serious, they must accept it like any other unexpected and unaccountable misfortune, but they could hardly believe it, and distrusted the guides who assured them that the misfortune had most certainly arrived. If the Times had announced that France intended the invasion of Great Britain, or Russia of India, they would have accepted the statement at once, but that America in certain contingencies meant war seemed incredible. Why should America mean war?

2. The very tradition of hostility between the United States and Great Britain had died away here. No-

body affects to regret the independence of America, nobody remembers the last war, nobody ever thinks about Canadian frontiers. The only feeling entertained is one of friendship, cool in some sections of society, warm in others, but everywhere existing, and so completely recognized, that in common parlance everybody draws a distinction between foreigners and Americans. To all continentals, and we fear to some Americans, it seems a little ridiculous or conventional to say so, but it is literally true that the sense of kinship with Americans never wholly quits English minds, that they dislike the idea of a quarrel as something unnatural and that the notion of having as a matter of duty to shell an American city makes them positively wince. The English are supposed on the Continent to be a brutal people, and doubtless there is a sense in which the charge has a foundation; but they are not brutal about Americans, but have a genuine and hearty dislike to any dispute with them other than a competition in prosperity, or in social experiments, or in good works. They watch all their kinsfolk do with permanent interest, sometimes appreciative, sometimes scornful, but always keen and active. They are always conscious, like members of the same family, of a certain rivalry, and always doubtful when surpassed in anything whether to be annoyed or full of hearty congratulations.

This is the real reason of that habit of giving advice which Americans think so patronizing, and which is no more really patronizing than the shouts of the spectators in a cricket field to "throw the ball up." The shout is half of warning, half of pleasurable excitement. The immense wealth of the Union, the way it seems to get through crushing difficulties, the sort of boyish confidence with which it meets every unpleasant incident, excites nothing but pleasure here, pleasure often, no doubt, expressed a little too much in the tone of the man who has passed through everything when speaking to a junior. To men in whom this frame of mind had been ingrained by forty years of quiet intercourse, the fact of a sudden rupture, not preceded as far as the general public knew by any warnings, seemed somehow monstrous, as monstrous as a blow from a kinsman delivered across a dining table. What in the world could be the excuse for an almost fratricidal struggle? If war should arise, the statement will not be believed, but not one Englishman in a hundred read Mr. Cleveland's message without a sort of gasp, as if he had a dim perception of some horror.

3. And then came in the Englishman's grand source of coolness, his common sense and knowledge of affairs. Nations cannot fight except for something, and what have Americans and Englishmen to fight for? Venezuela? Our kinsfolk are welcome to all the Venezuelas there are. There is probably no subject in the world upon which ignorance is in this country at once so dense and so cheerful as Spanish America. The man in the street knows nothing about it, not even its divisions, and is contented not to know. He is like a woman when cross-examined about arithmetic—quite unmoved, even when convicted of being unable to add up accurately. He would not be pleased to acquire a province there, not liking to be bothered with either Spaniards or Indians, and as for wanting any particular line of demarkation in Venezuela, he would, so far as the notion of property is concerned, give half British Guiana to anybody who wanted it without a qualm. Englishmen can be eagerly jealous when Russia shows signs of wanting to protect some petty Asiatic state beyond the Himalaya, but the United States may have all the influence they wish in Spanish America without Englishmen troubling themselves to read the telegrams. If they are suspicious of any power except Russia, it is France, yet when it seemed that France was about to cut a canal through Panama, and so acquire a predominant influence in Central America, they only cared to discuss the engineering obstacles.

For thirty years they have never so much as wished for anything in America, and war with nothing to get seems to them what Scotchmen used to call "a sinful waste of the mercies." Wanting nothing, they cannot see that Americans want anything either, for they do not believe in the stories of a design on Canada, which it would take half a million of soldiers to occupy, and they therefore set down the whole quarrel as unreal. If they must fight for their own they must, but they regard the necessity as they would regard the necessity for a chancery suit about a pond, as an intolerable nuisance adding heavily to the discomfort of life, and promising nothing except a permanent breach between families which ought to be neighborly. It is common sense as much as anything, if Frenchmen would only believe it, which has prevented Great Britain from flaring out because America has seemed to lose her temper. There is a prospect of an amazing waste of force on both sides, and it does not make Englishmen a bit more contented to know that their opponents will be mulcted as heavily as themselves. If they can have it without submitting to wrong or menace, they want peace.—London Economist, January 4.

A NEW FOSSIL PLANT IN THE COAL MEASURES OF NEW SOUTH WALES.

MR. R. ETHERIDGE, the distinguished curator of the Australian Museum, has described in the Records of the Geological Survey of New South Wales the occurrence of a plant in the Newcastle or upper coal measures possessing characters both of the genera Phyllotheca and Cingularia. The plant remains were obtained by Mr. J. B. Henson at Shepherd's Hill. The plant bed consists of light colored shale underlying a thick conglomerate. Between the latter and the shale there are four coal seams. In world-wide Phyllothecæ there have been at least three forms of fructification described, but with the exception of a possible inflorescence to which attention was drawn by McCoy in 1847, the fructification of the Australian species is unknown. It is now clearly proved by Mr. Etheridge that in the upper coal measures of New South Wales there occurs a plant, to all intents and purposes a Phyllotheca, possessing peltate organs identical in structure with the sterile bracts of Cingularia. The discovery certainly merits the attention of students of the fossil botany of the coal measures.

FLOATING SAND—AN UNUSUAL MODE OF RIVER TRANSPORTATION.

ON the eighth day of August last I joined a camping party at Bessemer, on the Austin & Northwestern Railway, 93·75 miles from Austin, in Llano County, Texas. This station is on the Llano River, a clear stream, tributary to the Colorado, flowing through what has been termed "the central mineral region." Inasmuch as the rocks bordering the river are, for the most part, Archean granites, both red and gray, schists, etc., the sand resulting from their disintegration may with propriety be termed "granite sand," even though composed largely of vitreous and pink quartz with only subordinate quantities of feldspar, biotite, and accessory minerals.

The morning after my arrival the river was found to be rising and, as I stood on the bank, at the point where we secured our water supply, I noticed a considerable froth and, what appeared to me at the time, scum passing down the stream. I spoke of the condition of the river to my companion, Mr. Laurence D. Brooks, of Austin, who remarked that what seemed to be scum was really sand. I thereupon went down to the water's edge and, dipping up some of the floating material, was astonished to find that the patches were composed of sand, mainly of quartz. At this time, half past nine or ten, the water supported a large number of patches, which varied in area from less than a square inch up to several square inches, all swept along by the current.

This phenomenon was witnessed only while the river was rising. When the water began to recede no more floating sand was seen. The reason for this will appear later.

Noting my surprise, Mr. Brooks stated that he had seen sand floating on some of the streams of Alabama, and that it had oftentimes been very troublesome in digging water holes. To test this statement I at once scooped out some holes in the damp sand and, surely enough, as their sides caved in, a few grains floated away on the surface of the water which immediately filled the holes. Between the grains there seemed to exist a mutual attraction in consequence of which they ultimately grouped themselves into small patches similar to the smaller patches seen on the river. In the meantime, Mr. Brooks, by gently sifting dry sand from his hands onto the water, succeeded in forming much larger patches.

A week later, when the river was well down and the sandy stretches of its bed had become quite dry on their surface, I gathered sand by the handfuls and sent it floating down the stream in such quantities that the sand rafts actually cast shadows on the bottom as they passed. Then I dug several large holes, as I had previously done in the damp sand, but with far better results, for, when their sides caved in, the dry grains forming the outer coat of the deposit were gently launched and floated off much more abundantly. Furthermore, as each mass of sand slipped into the water and, exclusive of the floating grains, sunk, the air contained in the interstices between the particles rose to the surface, forming a patch of foam or froth. The observations here made afforded strong proof of the probable explanation of the phenomenon of floating sand from a geological standpoint, the physical explanation being quite a different matter.

The bed of the river above Bessemer contains much sand and as the water rose, at the time mentioned, not from the occurrence of local rains, but from those at a distance, the edges of the sandy stretches bordering the flowing water must have slowly caved in, thus launching the dry sand, which floated away forming patches through the mutual attraction of the grains, while the damper masses, sinking to the bottom, contributed foam from the entangled air.

The only mention of floating sand at present known to me is that by Mr. James C. Graham in a brief article "On a peculiar method of sand transportation by rivers," published in the American Journal of Science, III, vol. xl, p. 476, Dec., 1890. The phenomenon was observed on the Connecticut River and is described as "a case of the transportation of siliceous sand upon the surface of the water, due to capillary floating." The sand in question was removed from a bar jutting out from an island. "The erosion was being carried on from the side of the bar against which the current did not strike. It took place by gentle ripple waves splashing up against the sand bar (which was at an angle of about 150° to the surface of the water) and upon the retiring of each wave a little float of sand would be on the water. At first these were about the size of a silver quarter of a dollar, but by the union of a number, some floats would be formed of about six inches square." The floating patches thus described by Mr. Graham are quite like those observed by me on the Llano River.

After I had read the above account I again (September 7) visited the river near Bessemer and was more than ever convinced that the explanation I have offered as to the manner in which the sand grains are launched is, for that locality, correct. I found places where the running water had cut down into the sand leaving overhanging cliffs, in miniature, varying from 3 to 6 or more inches in height. By pressure I forced a portion of this border farther outward, and, as the current completed the undermining, the mass slid into the water, which bore away many of the dry grains on its surface. Combining Mr. Graham's observations with my own, it would appear that dry sand may be naturally floated in at least two very different ways, viz.: First, by gentle ripple waves splashing up against a sand bar having an inclination of about 30°, as on the Connecticut River, and second, by the undermining of the sand beds bordering portions of a stream, as on the Llano River.

Though, as I have stated, the Llano sand was derived chiefly from the disintegration of granitic rocks, it effervesces slightly with dilute hydrochloric acid. This, however, is not surprising when it is known that metamorphic limestones also occur in this region. That granite fragments will float, and in a manner quite similar to this sand, I have demonstrated by breaking some red (Burnet or Capitol) granite in an iron mortar, until it had been reduced to a corresponding degree of fineness, and then gently sprinkling it from a paper onto the surface of the water. As might have been expected, much of it immediately sunk, but a sufficient quantity floated away to form a characteristic patch. Milky quartz when treated in a similar manner yielded even better results, as did orthoclase also.

How long sand will float, granting that the size and shape of the component grains admit of floating at all, I cannot say, but, should the surface of the water remain unbroken, I believe for an indefinite period. I base my conclusion on the following facts: In my laboratory I have floated sand in various vessels for hours. In one instance, for the sake of the test, I allowed the water, with its sand, to remain for more than a month undisturbed. At the end of that time, as might have been anticipated, owing to the evaporation of the water, many of the grains had become stranded on the sides of the vessel, yet quite a number were still floating.

How far sand will float is another question difficult to answer. Mr. Graham records his observations on the Connecticut River sands as follows: "These blotches were so numerous as to be very noticeable in rowing up the river and could be traced for half a mile or more below the bank, though this bank from which the sand came was but a few yards long."* I have not followed the Llano River rafts for so great a distance, though I have, with difficulty, traced them along the bank on several occasions—once for more than a hundred yards, when by the rippling of the current and the reflections of small waves caused by a slight breeze, they were lost to view. If the liquid is agitated to such an extent as to break the surface and to wet completely the floating grains much of the sand will drop to the bottom, though I have found that in a small vessel some grains have remained floating after a considerable stirring with a glass rod and after repeated shaking or jarring. At a point where a portion of the river had separated from the main stream and the water flowed quite rapidly, I started several series of rafts. As the velocity of the current increased and the ripples became stronger, the adhesion between the grains weakened until the rafts, as such, disappeared, though individual particles continued to be seen for some distance farther. Such being the case, we may expect that whenever a stream passes over any irregularity in its channel, such as rapids, even if very small, or waterfalls, the floating sand will sink; indeed, such a result may be looked for when the surface is disturbed by the wind.

Before proceeding further, I wish to say that the Llano River sand is not an extremely find sand, but, on the contrary, rather coarse. The grains are not, however, of uniform size. While some are small, many are comparatively large. The following measurements of four selected quartz grains will serve to indicate, approximately, the size of those that float:

	Greatest length.	Greatest breadth.	Thickness.	Weight.
1. Pink quartz	5 mm.	3·5 mm.	1 mm.	0·0231 grm.
2. " "	4 "	3 "	1 "	0·0141 "
3. White "	4 "	4 "	3 "	0·0304 "
4. " "	5 "	3·5 "	2 "	0·0179 "

The specific gravity of each of the ingredients of "granite sand" of course exceeds that of water, that of quartz being 2·5–2·8, of feldspar 2·44–2·62, of biotite 2·7–3·1. If these ingredients were present in the same proportions their average specific gravity, i. e., the specific gravity of the sand, would be 2·54–2·84, or, say, 2·69. The specific gravity of that part of the sand under investigation which had actually floated was found to be 2·59.

The attempt to explain the phenomenon, or possibly I should say phenomena, of floating sand from a physical standpoint involves the investigator in difficulty, so what I have to offer is tentatively given with the hope that as physical research advances, the subject may become better understood.

When shaded, it will be seen that the floating sand grains cause a depression of the water's surface, which, indeed, is quite as apparent in the case of isolated grains as in that of patches. I recall one instance where the depression, though of very short duration, possibly but a few seconds, was so great as to be positively startling. As I was sprinkling some sand upon the river, for experimental purposes, a pebble almost as large as the end of my little finger fell into the center of a floating patch, which, to my great astonishment and delight, was depressed, like a funnel, for, say, half an inch before the cause of this unexpected phenomenon broke through its surface and sunk to the bottom.

It appears from these and other observations that the weight of the sand grains actually depresses the surface of the water, yet the elastic reaction of that surface is sufficiently great to prevent them from sinking, especially when the resistance offered by their angularity is taken into consideration. In the launching of grains the more rounded would tend to roll over in the water and thus become wet, in consequence of which they would sink, while those of an irregular shape would overcome the tendency to roll and remain partially dry, thus fulfilling a condition necessary for floating. The angularity of the grains is conducive to the floating of the sand.

All my experiments heretofore having been made with water from either the Llano or Colorado rivers, it occurred to me that possibly a difference might be noticed in the surface reaction should other water be employed. I accordingly repeated several of my tests using rain water, Colorado River water, boiled and filtered, and distilled water, with little or no appreciable difference in the results.

The second part of the phenomenon, or, as I am inclined to regard it, the second phenomenon, is the formation of patches or rafts from the floating grains. Here the investigator encounters another difficult, yet interesting, problem in capillarity, viz.: The attraction, though largely apparent, existing between small bodies floating on a liquid. Leaving gravitation out of consideration, the usual explanation offered is as follows: The floating sand grains are not wet by the water, and when brought sufficiently near one another the depressions, in which they rest, unite, thus leaving between them an interval in which the water is below the general surface, hence by the pressure of the surrounding liquid they are urged together.†

* Loc. cit.

† For another and ingenious explanation see the paper by the late Professor John LeConte on "Apparent attractions and repulsions of small floating bodies." Amer. Jour. Sc., III, vol. xxiv, p. 416, December, 1882.

It seems to me, however, that the so-called attraction between the individual sand grains, as shown in the formation of rafts, is exerted over a greater distance than could be accounted for in the explanation above given. Thus I find that on an undisturbed surface of water they are brought together when separated by an interval as great as 4 cm., and that when scattered over the surface of a basin of water a foot in diameter they will finally form a single raft.

The observations made by Mr. Graham on the Connecticut River enabled him to reach the following conclusions:

1. They show that coarse sand can be floated away on a current of far less velocity than 0·4545 mile per hour.

2. They show a method of removing sand from the lower side of a forming bar which has gotten above high water mark.

3. They indicate a possible explanation of the coarse particles of sand found in otherwise very fine deposits.*

My own observations and experiments confirm conclusions 1 and 3. I find, in addition:

1. That sand grains will float in perfectly still water for an indefinite time.

2. That the grains which float are not necessarily siliceous. That flakes of mica, fragments of marble, bituminous shale, etc., also float, and that some of them, the marble and the bituminous shale, for example, are unusually buoyant.

3. That the property of floating is not confined to the sand of any particular locality, but depends to a considerable extent upon the angularity, i. e., the shape of the grains.

4. That whether sand will float or not depends, also, upon the mode of launching. Whether it be by ripple waves, as stated by Mr. Graham, or by undermining, it must be gently done, for should the grains be plunged into the water with sufficient force to completely immerse them, they will immediately sink.

5. That the natural conditions necessary to the floating of sand in rivers are somewhat unusual, depending, in the case of the Llano, upon a flood without local rains and, in that of the Connecticut, upon the manner in which certain waves strike a sand bar. It is quite possible, however, that floating sand is much more common than is ordinarily supposed.

6. That the physical explanation of the problem is complex rather than simple, and at best unsatisfactory in several important particulars, and that with the advance of molecular physics we may hope for a better understanding of what we now, for convenience, term "superficial viscosity" and "capillary attraction."—Frederic W. Simonds, in the American Geologist.

THE AFRICAN ATHERURA.

THE Zoological Acclimation Garden of the Bois de Boulogne possesses, at the present time, a very fine collection of rodents of various types—rabbits of all kinds, some short and others long haired, common squirrels and flying ones, prairie dogs, maras or Patagonian hares, pacas, agoutis, common porcupines and other animals of the same family that naturalists designate by the name of sphiggures and atheruras. It is especially to these latter, the atheruras, that we now desire to call the attention of our readers.

The atheruras, whose name, derived from Greek, signifies "animal having a tail terminating in a spike," are distinguished, in fact, from the ordinary porcupines, because, instead of a rudimentary caudal appendage, they have a tail that equals a third or a half of the length of the body and is provided at the extremity with a tuft of flattened horny tubes more or less shriveled. These singular productions, the form of which varies somewhat according to the species, recall, by their aspect and color, strips of irregularly slit parchment or culms and grains of dried grasses. They are, however, of the same nature as the hairs and have the same origin. For the rest of its length, the tail is covered with scales intermingled with hairs. The latter gradually elongate in such a way as to establish a transition toward the terminal tuft.

A large portion of the body of the atheruras bristles with quills, which, although not as closely set or as long as those of the porcupines, nevertheless constitute a formidable armament and render the handling, not only of the living animals, but also of the stuffed specimens of collections, difficult and even dangerous. These quills acquire their greatest development upon the median and posterior parts of the body and gradually diminish in length toward the sides of the neck. Upon the head and limbs they revert to the state of simple hairs, which are slightly harder than those that form the principal part of the coat. The longest quills terminate in a sharp point and are flattened above and below. Besides, their edges are slightly thickened, so that they somewhat resemble a dagger having a longitudinally hollowed blade. Finally, in certain species, these defensive weapons are finely toothed or rather barbelate laterally.

The atheruras are of smaller size and of less heavy build than the ordinary porcupines Their head is smaller and their body is more slender, and they rather resemble cats provided with a spiny armor. Their head is somewhat elongated, with ears of medium size and a snout provided with a pair of long mustaches.

These singular rodents are found on the one hand in the south of Asia and on the other in tropical Africa, and, in each of these regions, constitute one or perhaps two distinct species whose characters are furnished by the form of the quills and horny appendages at the extremity of the tail. Thus, Messrs. Gervais and Günther distinguish, along with the long tailed atherura of Linnaeus (Atherura macrura) which inhabits the islands of Sumatra and Java and is known to the natives as the "landak" or "landa klœle," the penicillate atherura of Waterhouse (Atherura fasciculata), which is confined to the kingdom of Siam and differs slightly from the animal described under the same name by Shaw and Gray, and assimilated later on to the long tailed atherura. In the latter, which Buffon calls the "porcupine of Malacca," the terminal appendages of the tail exhibit the form of simple and slightly undulate fillets, while in the penicillate atherura they become constricted here and there. So too, according to Paul Gervais, there is in Africa, along with the African atherura of Gray (Atherura Africana), which was discovered at Fernando Po, a second species, the armed atherura (Atherura armata), the type of which, indigenous to Gaboon, was given to the museum by Mr. Aubry Lecomte. Such is also the opinion of Mr. A. T. De Rochebrune, who, in his Fauna of Senegambia, published a new description and a figure of the armed atherura. This animal, of the size of a cat, is of a somewhat undecided color—of a brown varied with yellowish and blackish. The gray quills, which in a state of rest are for the most part directed obliquely backward, are in fact white or slightly yellowish in their first half and brownish at the extremity. The limbs are of a blackish brown, and the lower parts of the body, as well as the sides of the head, of a yellowish white. The tail, covered at the base with strong quills, black above and yellowish beneath, is brown in its scaly portion, with a few black hairs, and terminates in a tuft of horny appendages of a yellowish white. These appendages have nearly the same form as in the penicillate atherura, and exhibit a series of inflations separated by constrictions, and somewhat resemble oats.

* Amer. Jour. Sc., III, vol. xl, p. 478.

An analogous arrangement, which our figure but partially renders because of its reduced size, is found in the African atherura. In this species, the upper parts of the body, the external surface of the limbs, the top of the head, the face and the nape are of a dark brown, and the breast, the abdomen, the throat and the internal surface of the limbs of a grayish white, varied only by a dark stripe in front of the fore legs. The quills begin to show themselves upon the back of the head, where they are scarcely more than an inch in length, and extend over the entire dorsal region, where some of them attain a length of five inches. All are marked with a longitudinal groove and terminate in a sharp point. Their color varies from white to

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uniform black, but the skin into which they are set, and which is covered with sparse hairs, appears entirely white. Here and there, between the quills, are distinguished a few stiff and slender bristles. The eyes are small, but as bright as jet; the ears are bare and of rounded shape; and the mustaches are very long. The body measures from 12 to 18 inches in length and the tail from 5 to 6 inches.

It is certainly to this species that belongs one of the two atheruras owned by the Garden of Acclimation. The other, which seems to be slightly different, is, perhaps, referable to the second African species of atherura, the Atherura armata. We say perhaps, since, in order to well appreciate the distinctive characters of the atheruras, it would be necessary to have to do, not with individuals living and inclosed in a cage, but with skins and skeletons. The two African atheruras are, moreover, found side by side, it is said, in the same countries, especially in Casamance and Gambia, according to Mr. De Rochebrune, where they are confounded by the natives under the name of "n'got n'ga."

The Atherura Africana exists also in Gaboon, where it has been met with by Mr. Alfred Marche in the country of the Okandes, in Sierra Leone and in the island of Fernando Po, where it was but recently very common, and into which it does not appear to have been introduced by the Portuguese. Quite recently it was even thought that the area of its habitat might be prolonged quite far from the east coast, as far as to the country of the Monbouttous; but, if we are not deceived, the specimens obtained in this part of equatorial Africa by the famous Emin Pacha have just been referred by Mr. O. Thomas to a distinct species—Atherura centralis.

In the country of the Monbouttous the atheruras are known by the name of "kolia," and form part of the food of the natives. The same is the case, it is said, in Fernando Po. It is from this island that came the first living specimen seen in Europe. This individual, captured by Lieutenant Vidal, of the English expedition sent to take possession of the island, arrived in London along about 1829 and lived for some time in the Zoological Gardens, where it was studied by Mr. Bennett. Other animals of the same species were afterward brought to England and Germany and were preserved for longer or shorter periods in the zoological gardens of London and Hamburg.

In captivity, the atheruras are morose animals that remain immovable or squat in their litter for the greater part of the day, and that remain inactive until the approach of night, when hunger presses them. They then run quite rapidly in their inclosure, in carrying the tail and quills slightly erect, but it is only when they are inquiet or irritated that they bristle after the manner of porcupines. At the same time they stamp their feet with anger and agitate their tail, the terminal appendages of which strike each other with a noise as of dry leaves.

A male and female inclosed in the same pen, in the Zoological Garden of Hamburg, lived in perfect harmony, lay side by side and aided each other in making their toilet, but another couple, according to Brehm, presented one day the spectacle of a terrible domestic drama. The male, not very gallant, having seized a tit-bit and claiming it for himself, the female tried to snatch it from him, and, in the squabble, killed her mate with a savage bite.

The atheruras recognize those who take care of them and easily get accustomed to take their daily food with their paws, but they are certainly creatures of but slight intelligence and are much less interesting by their habits than by their organization and their geographical distribution. It is strange, in fact, to find representatives of the genus Atherura in countries so remote from each other as Western Africa or the equatorial provinces of Eastern Africa and the peninsula of Malaisia or Indo-China, while the intermediate regions, that is to say, India, properly so called, and Persia, are entirely devoid of animals of this group. But, as Mr. Günther remarks, the fishes offer us analogous facts, and, as we have already had occasion to observe, the birds of the genus Pitta are also found in the same case, since one of their species lives in Congo and the country of Angola, while all the others are distributed through Malaisia, Indo-China, the Philippines, Papouasia and Australia. Paleontology alone is capable of giving us the key to such anomalies in the present distribution of the vertebrates.—E. Onstalet, in La Nature.

A CURIOUS CASE OF COMMENSALISM.

IT is interesting to note the tendency that exists among the majority of living beings to associate in order to fight against destruction. Such associations are generally formed among animals that simply put their existence in common. This is the case with communities of ants, bees, etc. At other times they are formed in a more intimate manner by the union of bodies, which hence communicate with each other in a permanent or a temporary manner. Such is the case with colonies of ascidians, bryozoairans, etc. In either case the association is formed between animals of the same species; but it may also exist between individuals of different species, and the phenomenon is then called commensalism. Examples of commensalism are not very frequent. An attentive examination of the association shows that in some cases the benefit is not as reciprocal as one might believe at first sight, and turns almost exclusively to the profit of one of the two associates. It is then no longer commensalism, but parasitism.

It would be an error, however, to think that commensalism does not exist. The finest example that can be mentioned in this regard is that of the association of the hermit crabs with certain ascidians. We shall say a few words concerning these apropos of a work of Mr. Faurot, who has cleared up and completed certain points of their history.

The hermit crab, as well known, is an asymmetrical crustacean that lives in the empty shells of certain mollusks, and especially of the buccinums. Now upon these latter we very often find sea anemones, and almost exclusively upon those inhabited by the hermit crab. We know two species of these actinias: one of them, the Sagartia parasitica, lives upon shells inhabited by crabs known scientifically as Pagurus Bernardus, P. striatus and P. angulatus. The other is the Adamsia palliata; it lives in the shells inhabited by the Pagurus Prideauxi.

Like all the actinias, the Sagartia parasitica is composed essentially of a fleshy column that terminates at the top in a bouquet of white tentacles. It is remarkable by the presence of orifices placed at the lower third of the column and allowing the gastric

cavity to communicate with the exterior. Its fixation is effected simply by the foot disk acting as a sucker. When there is but one Sagartia upon a shell, it is found upon the side nearest the crab. But there are often several—as many as seven or eight—and then the foot disks, which touch each other without overlapping, cover nearly the entire shell.

What are the relations of the crustacean and actinia? Is it simply chance that causes them to live side by side, one within and the other outside of the shell? It is rather thought, and it is almost demonstrated, that the two are united in order to render each other assistance. The actinia is evidently useful to the crab in defending the approaches to the domicile with its numerous tentacles, which are true batteries of stinging capsules always ready to strike down importunate would-be hosts with its myriads of nematocytes. As for the crustacean, thanks to its long limbs, it can stir about and seek food. The actinia, which has neither legs nor eyes, profits largely by such movements and especially absorbs the remnants of the crab's food. Certain naturalists have even asserted that the crab, from time to time, feeds the actinia directly; but this is doubtless an invention.

It is not the whole truth to say the union of the crab and the sagartia constitutes an amicable association; it is necessary also to demonstrate it, or at least to give proofs in support of the assertion. Mr. L. Faurot has undertaken some experiments upon this subject. "After," says he, "having verified Percival Wright's observation, according to which a Sagartia parasitica abandons the shell whence a Pagurus has been extracted, and that too in a relatively short time (thirty-six hours at the most), I have found that the Pagurus itself is not indifferent to the loss of its companion. When, in fact, after removing the Sagartias fixed upon a shell inhabited by a Pagurus, we put the latter in the presence of another shell that is empty and covered with its preferred actinias, we soon see the crustacean leave its lodging. In this case, much more quickly than if it had to do with shells completely deprived of Sagartias, it will explore the interior of it with its claws and insert its abdomen, which is provided with two hook legs with which it will affix itself to the last revolution of the spiral.

"When a Pagurus inhabiting a cassidaira, from which the Sagartias had been removed, was put in the presence of other Sagartias that were fixed either upon the glass sides of an aquarium or upon stones, I have often been witness of the maneuvers by means of which the crustacean succeeded in associating itself with such actinias.

"One of the latter is seized with the claws of the Pagurus, which agitates them as if it had to check the resistance of a prey capable of escaping. These motions, long continued, produce in the first place a retraction of the actinia, and afterward cause its foot disk to let go its hold of the surface to which it is fixed. As soon as the actinia is detached, the Pagurus clasps it between its legs and the cassidaira until the disk has become fixed to the crustacean's abode." The actinia gradually crawls over the shell and places itself upon the side nearest the crustacean.

The commensalism of Sagartia parasitica and Pagurus Bernardus is therefore very clear. It is at least as much, if not more so with Adamsia palliata and Pagurus Prideauxi. Here each shell carries but a single actinia, but with a very wide foot disk, which is concave and envelops the domicile almost entirely like a mantle. Furthermore, the shell is very often not large enough to completely shelter the crustacean. It is then that the actinia, which, prolonging itself beyond the substratum and secreting a solidifiable mucus, becomes the true abode of the crustacean. The Sagartia, on account of its foot disk deformed by commensalism, cannot live elsewhere than upon shells inhabited by Pagurus. The association is therefore very intimate, and very advantageous to the hermit crab, which has thus a light and well defended house. It is also very useful to the actinia, which is placed on the ventral side with respect to the crustacean, and the mouth of which is almost in contact with that of the latter.

"The Adamsia palliata, as well as the Sagartia parasitica," says Mr. Faurot, "does not content itself with the leavings of the crustacean; it is mouth to mouth with its host, and sometimes ingests the greater portion of the prey that the latter is endeavoring to divide into bits in order to allow them to enter his jaws. The Adamsia palliata cannot live solitary and never dissociates itself from the Pagurus Prideauxi.

Separated from their companion, the actinias soon die, but the Pagurus continue to live. If we place a Pagurus Prideauxi in the presence of a large empty cassidaira shell, it will immediately take shelter therein. Although its new abode may have stronger walls than those to which it has been accustomed, it will abandon it if care is taken to place near it Adamsias recently separated from their host. They invest themselves with these actinias, even though the latter are not proportioned to their own size, so that they often leave a portion of the body exposed, like one who wears too short clothes." In this operation, the crustacean makes use of its claws and holds the actinia until it has become fixed.

In Fig. 2 we represent a Pagurus pilimanus (a species collected several times by the Challenger and the Talisman) carrying a very curious commensal upon its shell. This commensal is an elegant polyp of a beautiful violet color, the Epizoanthus parasiticus, which has the faculty of budding and forming colonies. At the bottom of the sea, empty shells are not very abundant, so the Pagurus would find it difficult to discover shells proportionate to its size. Fortunately for it, the small colony that lives upon the original shell grows and supplies it. More than this, the shell is gradually dissolved, and finally we have no longer anything but a Pagurus surrounded by a living coat of Epizoanthes. —Henri Coupin, in La Nature.

FIG. 1.—HERMIT CRAB LIVING IN COMMENSALISM WITH ACTINIAS.

FIG. 2.—DEEP SEA PAGURUS COVERED WITH A COLONY OF EPIZOANTHES.

SOME EFFECTS OF FROST.

By W. E. PARTRIDGE.

MANY persons who closely observe the destructive effects of frost in winter are puzzled by great diversity in results which follow the freezing of water. It does not appear to follow any law in its action, whether it be confined in pipes or closed vessels, or unconfined, as on the ground and in the rivers and ponds. In some cases pipes are frozen repeatedly without injury, and in other cases bursting follows a moderate frost. These and many other curious facts do not seem to be explained by the simple popular statement that water expands on freezing. While it is true that water expands when it changes from the liquid to the solid form, there are several other facts in connection with this one which must be known before the subject can be clearly understood.

Water is nearly incompressible. That is to say, its bulk cannot be reduced by the application of pressure, except in the smallest degree. A pressure of one atmosphere (14·7 pounds per square inch) reduces the volume of water only 1-47,500,000 part. Even this small reduction may be due to the presence of some gas like argon, which the experimenters may have been unable to remove. For all practical purposes its bulk is unchangeable by any pressure which can be put upon it.

Water, unlike most substances with which we are acquainted, does not expand and contract according to a uniform law when heated and cooled. It contracts quite regularly when cooled until the temperature of 39·2° Fah. is reached. Then, if the cooling is continued, it begins to expand, and continues to do so until the temperature is reduced to 32°. At this point the water becomes ice and a further expansion takes place. The bulk of the ice is then 8 per cent. (0·0855) larger than that of the water from which it was formed. Continuing the cooling, the ice expands instead of contracting, as would be expected, until the temperature falls to 24° Fah. Upon further cooling, the ice behaves like other substances and contracts regularly with the fall of temperature.

Reversing the operation and applying heat to the ice, expansion takes place in the usual way until 24° Fah. is reached, when the ice begins to contract. The contraction continues up to 32°, when the ice melts. The shrinking is, of course, equal to the expansion which took place in freezing. Still further heating diminishes the bulk of the water up to 39·2°, when it begins to expand and continues to do so, following the common course of liquids and other substances. Water must be heated to 46° before it has expanded so as to be equal in bulk to that which it had at 32°. Ice, after expanding down to 24° Fah., shrinks on cooling, and when 16° is reached, has the same volume as water at 32° and 46°. Water at 46° and 32° and ice at 16° have the same density, that is to say, one cubic foot has the same weight.

An alteration in the pressure upon water has a very important effect upon the freezing point. Each increase of only one atmosphere (14·7 pounds per square inch) pressure lowers the freezing point 0·01½ of a degree. A French experimenter kept water liquid by a pressure of 13,000 atmospheres, though the temperature was —5° Fah. The same experimenter, Mouisson, melted ice at 18° Fah. by the same pressure.

Changing shape (expanding or contracting) under the influence of heat and cold, ice does so to a greater degree than any of the metals or other solids usually met with. It expands or contracts about 3½ per cent. of its length for each degree Fah. which it is heated or cooled.

Stated more simply, water expands when cooled below 39·2° Fah., and at the freezing point undergoes an expansion of about 1-12. The ice expands if cooled, and reaches its greatest bulk at 24°. It has to be cooled to 16° to have the same bulk as it did at 32°.

Bearing all these facts in mind, it is not so difficult to understand the strange results which follow the freezing of water, if it is also understood that ordinary ice crushes only under a pressure of about 30,000 pounds per square inch.

One of the most common incidents of the modern house in the winter time is the freezing of the water pipes. Usually the service pipe is the most liable to this accident. If the pipe bursts, it is the expected which has happened. The reason appears obvious.

But it often happens that the pipe does not burst, even though the ice stops the flow of water. So the pipe leading from the street main to the house frequently freezes solid and remains in that condition for weeks without injury. How can such facts be reconciled with the expansion of water when freezing? How, too, does it often happen that a single cold night may cause one pipe to burst in a dozen places?

When a pipe is cooled the water contracts and the density increases until the maximum is reached at say 39° Fah. If the cold has reached the pipe at only one point and the intensity has not been great, the expansion below that point has been slow and the water has been forced back toward the street main, or out at the faucet, if it has been allowed to drip. The ice, when it began to form, has done so at a very slow rate, and the water has been forced away to make room for it. The strain on the pipe has, therefore, been very small. In general, when the freezing is very slow, the strain on the walls of the pipe or vessel is not great, if the water and ice have room for expansion in the direction of the length of the pipe. Freezing under the conditions named may take place over and over again without bursting the pipes.

The freezing of underground service pipes in the streets is nearly always under the conditions just described. The heat is extracted from the water very slowly, while the water can be forced back into the street mains without difficulty.

A slight change in the conditions, however, produces entirely different results. Let the pipes be gradually cooled, so that when 39° is reached they are filled for their whole length with water of the greatest density. Then let the first freezing take place at the outer wall. The whole, or nearly all, of the water will then be in condition to undergo the greatest possible expansion. If the freezing be progressive and slow the pipes may be burst in a dozen places, and masses of ice may project from the cracks. In such cases the water has its freezing point slightly lowered by the pressure within the pipes. When the metal gives way the water is instantaneously converted into ice, even while in the act of being projected from the openings in the pipe.

In the case of iron pipes, which yield very little, the destruction is usually greater than in lead. The latter pipes frequently stretch under the slow expansion of the ice, so that they take little injury.

The continual expansion of ice with the fall of temperature accounts for the more destructive action of a "hard freeze" than that of a light one. "Freezing and bilging" is a common term in some parts of the country. It is used to denote a swelling up and splitting of the ice itself when sudden freezing is accompanied by a great fall in temperature. The expansion of the ice forces a portion of the surface upward in a low, flat mound two or three inches in diameter.

The expansion of the earth by freezing often produces queer phenomena. At times the whole surface of a wet field will be lifted from one to two inches and supported on small pillars of ice. The expansion in freezing is, for reasons connected with the mode of crystallization, which cannot be explained here, exerted entirely in an upward direction. The lifting and expanding action of the ice in opening the ground causes the disappearance of the water which has been standing on the surface of the soil in the spring of the year. After a night of hard frost all the little pools disappear, to return later in the day as the ice melts.

In open vessels, like pails, bowls, pitchers, etc., ice becomes very destructive. When the water within them has reached its greatest density, a thin layer of ice may be, and usually is, formed on the surface, which has cooled faster than the body of water. The ice thickens and the water below exerts the greatest possible pressure in all directions. In very cold weather, the central part of the ice is forced upward by the expansion. In most cases the surface of the ice will be slightly raised in the center. This, of course, depends, to some extent, on the conditions of cooling.

The final condition of freezing is a surface covering of ice and a lining of the vessel with a thick coating, the expansion of the latter often forcing out the bottoms of pails, etc.

The destructive action of ice upon rocks, buildings, trees and engineering structures can be easily understood. With an expansive force which, at its lowest limit, is 30,000 pounds per square inch, every crack into which water can fall and where it can freeze is converted into a wedge. As the temperature falls lower and lower, ice becomes more and more solid and has an enormous increase in strength. No figures can be given, because no experiments have been made, but at —30° Fah. the stress required to crush ice must be nearly three times as great as at 32°, and it will have a correspondingly increased disruptive action. The figures given indicate that water confined in a crevice in an inelastic substance would at —18° Fah., when freezing under pressure, exert a force of about 2,000,000 pounds per square inch. With a sufficient degree of cold the power of water appears to be practically irresistible, since no known substances are capable of overcoming or retaining the pressure which it can exert.

DESTROYING INSECTS BY ELECTRICITY.—Some successful experiments for destroying moths, etc., in forests were made a little while ago in Saxony. A revolving search light was erected and set to work. Large numbers of insects were attracted and were then killed by an incandescent platinum screen, which was fixed around the lamp.—Electrical Engineer.

[Continued from SUPPLEMENT, No. 1047, page 16730.]

THE ARC LIGHT.*

By Professor SILVANUS P. THOMPSON, D.Sc., F.R.S.

LECTURE I.—Continued.

LOCATION OF THE BACK ELECTROMOTIVE FORCE.

ANOTHER point which remained doubtful for a long time, even after Edlund had made his observations, and these measurements had been made, was whether this fixed voltage that appears in the arc was really the back electromotive force, as Edlund supposed, or whether it was a "transitional" resistance—a sort of resistance located at the surface of transition, which, instead of being a constant, as resistances usually are, varied inversely as the current. That was, indeed, Schwendler's view. Schwendler said here is a resistance which varies inversely as the current; when you double the current, the resistance goes down one-half, therefore you want exactly the same voltage as before to drive that double current through. After all, it may be only a facon de parler to call this by either name, but at any rate, reasons can be adduced in favor even of so improbable a view. Suppose there is a surface between a solid on one side and a vapor on the other. Apart from any question of evaporation going on or matter being given off from the solid into vapor at that surface, there is at that surface a difficulty in the current getting out from the material in one state to the other; that resistance will be, other things being equal, inversely proportional to the surface. One square mm. of surface will offer a certain amount of difficulty; with two square mm. you will have two possible paths, and the difficulty of transition will be halved. If there is anything that goes by area, then, if the resistance is transitional, as it is supposed to be, it will vary inversely as that area.

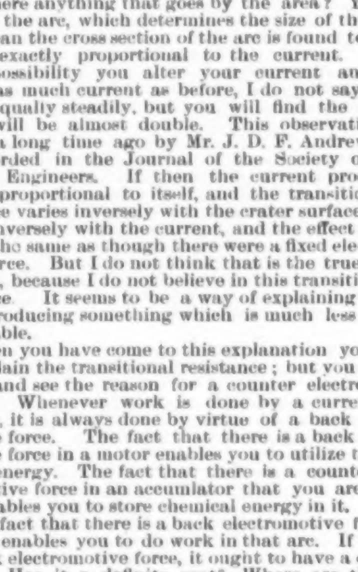
Is there anything that goes by the area? Yes; the size of the arc, which determines the size of the crater—I mean the cross section of the arc is found to be almost exactly proportional to the current. If by any possibility you alter your current and pass twice as much current as before, I do not say it will burn equally steadily, but you will find the crater's area will be almost double. This observation was made a long time ago by Mr. J. D. F. Andrews, and is recorded in the Journal of the Society of Telegraph Engineers. If then the current produces a crater proportional to itself, and the transitional resistance varies inversely with the crater surface, it will vary inversely with the current, and the effect will become the same as though there were a fixed electromotive force. But I do not think that is the true explanation, because I do not believe in this transitional resistance. It seems to be a way of explaining a thing by introducing something which is much less understandable.

When you have come to this explanation you have to explain the transitional resistance; but you can explain and see the reason for a counter electromotive force. Whenever work is done by a current in a circuit, it is always done by virtue of a back electromotive force. The fact that there is a back electromotive force in a motor enables you to utilize the electrical energy. The fact that there is a counter electromotive force in an accumulator that you are charging enables you to store chemical energy in it.

The fact that there is a back electromotive force in an arc enables you to do work in that arc. If there is a back electromotive force, it ought to have a definite seat. Has it a definite seat? Where are these 39 volts? Are they at the crater surface; are they distributed all along the arc; are they at the negative peak? That was one of the points which was entirely uncertain until a few years ago. Several of us have worked at it, Prof. Fleming and Prof. Ayrton, among others.

An observation which I made some years ago was communicated to the electrical engineers at the time. I made an arc in the usual vertical way, with the positive carbon at the top. In Fig. 4, in order to plot

FIG. 4.



volts vertically against lengths horizontally, the arc is represented as turned over on its side; and the distance between positive electrodes is greatly exaggerated. Into the space between the crater and the peak I then introduced a third carbon to act as an explorer.

The difference of potential between the two points as measured with a voltmeter was about 45 volts; and to measure this the wires of the voltmeter must be connected, the one to the negative, the other to the positive carbon. But if one wire is connected to the negative carbon and the other to the third or exploring carbon, one is enabled to go fishing about to find how this 45 volts of potential difference is distributed along the arc. If the arc merely operated as a plain resistance, the fall of potential would be found to be distributed along the length equably; when the exploring carbon had been moved through half the length, the voltmeter would just show 22½ volts. But nothing of the sort is found.

At a point half way along the potential was found to be about four volts higher than the negative carbon; and as the third carbon was moved toward the crater, this rose to nearly six volts. This process, then, enables one to locate the whereabout of these 39 volts of back electromotive force. Suppose one plots out vertically the results of the observation (as in Fig. 4), the high level line to represent the potential of the positive carbon, the low level line the potential of the negative carbon; then the volts drop from high to low, somewhere or other in the distance from crater to peak.

We might, of course, have measured the voltage drop from the positive carbon downward, instead of measuring it from the negative carbon upward. This method of exploration is precisely similar to that known and used for years in examining the polarization of secondary batteries. Inspection of the diagram that has been plotted from the observations shows that there is a drop of something like 39 volts at the crater, and then there is a slight regular drop all the way down the arc, due to the fact that there is current going through resistance; then there is a slight drop at the other end of the peak. I measured that slight drop to be two or three volts; but in one case, where the arc was hissing, I found at that place a slight rise. Other observers* have also obtained a rise at this end, showing that some inverse phenomenon is going on there. The same kind of thing occurs frequently in electrolytic observations. One finds the potential of the intermediate liquid lower than that of either of the materials at the two ends.

If there were a hissing arc instead of a silent one, the drop at the crater would be found to be only about 13 volts there, and the whole voltage from one side to the other would be very much less. Many years ago the observation was made by M. Niaudet that the current, if supplied under certain conditions, increases at the moment when the arc begins to hiss; if supplied under certain other conditions it, however, decreases at the moment when the arc begins to hiss. This apparent back electromotive force has not only been a puzzle to the investigator, but it has led to several fallacious suggestions.

There is a remarkable paper in the Comptes Rendus for 1884 by the late Prof. Jamin. Jamin was an intelligent man, but he formed this extraordinary opinion that an alternating current arc would necessarily be much more efficient than any arc could possibly be when produced by a continuous current, whether from a battery, an accumulator or anything else. For, said he, if you work with a battery or an accumulator, that current always flows in one direction, and you have 39 volts against you; that means a pure loss of energy which is thrown away; whereas if you work with a rapidly alternating current, the back electromotive force will help you at each reversal of the current. Therefore, the alternating current will be very much more efficient. Of course, the whole thing is a mare's nest. Jamin did not understand that the essence of getting work out of a current, whether from a motor or an arc, was to have back electromotive force.

Another matter which has never yet been properly cleared up is the transport of matter across from one side of the arc to the other. Unquestionably in a hissing arc there is a large transport; particles of carbon in solid or liquid state being visibly projected across the gap to form the mushroom on the negative peak. Besides this bodily transport, there is probably also a molecular transport by evaporation at one side and condensation at the other. But the hissing arc is not the normal phenomenon, and the transport of actual particles is abnormal. In a silent arc there is very little. You may, in fact, substitute as a negative pole a piece of metal, if you keep it cool and prevent it from melting. The evaporation of carbon at the positive surface is quite sufficient to keep the arc going. However, some researches have been made on this point. Sir William Grove thought he got a transport in both directions, as did Matteucci, who employed, instead of carbon, a pole of iron and a pole of copper. On examining the two surfaces after an arc had been allowed to play across, he found that some carbon had been carried over to the iron and some iron had been carried on to the surface of the copper. But the spluttering effects one gets when using metals in this way make one very unwilling to accept such results as conclusive.

A recent experiment of M. Blondel in photographing the image of the arc proves, if anything can prove, that there is only one direction in which material is ever transported, and that is from the positive side to the negative—from the crater to the peak.

ALTERNATE CURRENT ARCS.

I have the means here of showing an alternating current arc. We will turn on the current from the London Electric Supply Company, and I will show the alternating arc first by means of one of those nearly obsolete devices, one which has now become almost a museum curiosity, a Jablochkoff candle. All honor to Paul Jablochkoff. In the year 1877 he revived this elementary method of providing for an arc; avoiding all mechanism by simply putting the two carbon pencils parallel at a suitable distance apart, one by the side of the other, with a bit of plaster between. On switching the candle into circuit the alternating current passes from one point to the other after being started by a temporary bridge piece. Jablochkoff used the alternating current, simply because it was essential that the consumption should be equal at both tips. In the use of the alternate current the actions at the tips reverse at every reversal of the current. For an instant the current flows in one direction, then reverses, only to reverse back again. For a brief time the crater will be forming on one tip, and the negative peak on the other; then, a very small fraction of a second afterward, the action is reversed, and so the two carbons are consumed away at equal rates. But, for my own part, I do not admire the light from the Jablochkoff candle. It always roars and hums because of the alternations that are going on. The light is down in a hole between two carbons, so that it is not diffused in the most satisfactory or economical or agreeable way.

HIGH VOLTAGE ALTERNATING ARC.

While I have an alternating current here I should like to show you another arc phenomenon that is not often seen, at any rate outside electric lighting stations. I refer to the alternating current arc at 2,000 volts. The arc that one gets from a current when elevated to such a high electromotive force as that will be very much more like that which Davy produced with his charcoal points and his battery of 2,000 cells. That is to say, it will be a real arch of flame between two points, and this arch will be blown upward by the ascending current of air. You will notice that the whole arch itself is more or less luminous. You see that we get great roaring flames, but you will be astonished to find how little carbon is consumed by this 2,000 volt arc. In fact, the higher one goes in voltage with the arc, the less carbon is consumed, and, in some cases, the less light you get. But the consumed carbon is very small, and these flames appear to be rather of the nature of true flames. Only there is this difference: Instead of taking combustible materials, putting them together and burning them in order to get out heat, you are taking materials which do not ordinarily burn together, viz., the two constituents of the air, nitrogen and oxygen, and you are forcing them to burn together by pumping heat into them. It is an endothermic flame, instead of the ordinary exothermic flame. It is a flame which takes in heat from the current, which requires to be fed with heat, in order to exist at all. Certainly some of the luminous phenomena one gets with high voltage, and at high frequency, are of this nature, and, therefore, are not like the true arc. In the arc itself, when made in the air, undoubtedly there is a combustion of the air, that is to say, the oxygen and nitrogen of the surrounding air are burnt together by the heat, and also both of them combine with carbon.

CHEMISTRY OF THE ARC.

The chemistry of the arc has never been thoroughly worked out. Prof. Dewar, among others, has worked at it, and shown that not only do you have carbonic acid and carbonic oxide produced, but nitrogen compounds, prussic acid, cyanogen, nitrous acid and various others. He drew off the gases through tubular carbons and analyzed them.

I do not think any one has in any record called attention to the smell of the arc lamp. The arc certainly has a very characteristic odor, probably due to the fact that the carbon is combining both with nitrogen and with oxygen, and that the nitrogen and the oxygen are combining together, giving rise to compounds which, though more or less poisonous, are happily produced in very small quantities and give a decided odor to the air where an arc is being made. These flaming arcs at high voltages very soon produce a perceptible odor; whereas a normal arc, produced actually by 40 to 50 volts, gives very little smell indeed, and sets free extremely little of the disagreeable nitrogenous products.

MAGNETIC PROPERTIES OF THE ARC.

Among the early things that Davy discovered was the effect of a magnet on the arc. He showed that the arc behaved like a flexible conductor, and a magnet being put near it caused it to bend to one side or the other. If the current in it is ascending, it is bent to one side in the magnetic field; and if it is descending, the arc is bent to the other side. In the case of the horizontal arc, it makes a difference whether the current is flowing eastward or westward. In the one case the earth's magnetic field tends to bend it up and in the other case it tends to bend it down. As a consequence, you can get a larger maximum length of arc with a given current, if the current comes in at the east and goes out at the west, than if it comes in at the west and goes out at the east. Also with an alternating current arc, where the current flows alternately up and down, the flame of the arc is literally pushed on one side. If you examine an alternating current arc in a mirror that rotates round a horizontal axis, so as to get a succession of images thrown out vertically, you will find that those images are successively curved right and left, owing to the effect of the earth's magnetism. Walker and De la Rive observed the arc to rotate round a magnetic pole, and a number of kindred experiments have been made which are very curious. I will only show you one. Here is an electro-magnet which I can introduce into the circuit. I will take a pair of carbon pencils, and, placing them between the poles of the magnet, I will try to obtain the arc, using 40 or 50 volts in the arc circuit. You know that ordinarily the arc goes out if the carbons are parted too far. When it does go out it does not make much noise; there is a slight sound like that heard when a candle is puffed out. But try it between the poles of that magnet, what do you find? You cannot even get the arc to keep alight. It flops out instantaneously with a sound almost like a pistol shot. The flame is blown inward or outward, according to whether the current is flowing down or coming up. You notice that I put one carbon at the top and the other at the bottom, and then the magnet blows the flame outward. If I reverse the carbons and put the negative at the top, the flame will be blown inward. Even if one works at some distance away from the poles of the magnet, you still observe this very peculiar effect. To burn the arc steadily in a strong magnetic field is almost impossible. If I had a larger electromotive force, say 300 or 400 volts, so that I could support a long flaming arch between those two carbons, and were to form such an arc, it would be blown out sideways, like a blowpipe flame. This was observed long ago by Quet in 1852, and in 1874 by the late Mr. Werdermann, who proposed to employ it as a sort of blowpipe. He set two carbons side by side, like a Jablochkoff candle, and arranged a magnet to blow out the flame in a long tongue for use in soldering or lead burning, instead of a blowpipe. Recently others have combined magnets with arcs for the purpose of making electric blowpipes. The Benardos process of electric welding and forging is based on this particular use of the arc.

NON-ARCING METALS.

It has often been noticed that certain metals will hardly arc at all in a continuous way. If you take two solid cylinders of zinc, or two cylinders of antimony, and put them close together, and connect them on to the electric light mains, and then start an arc, by sparking across, the arc will not maintain itself. It splutters itself out instantly. This property has been made use of in America, where atmospheric disturbances are much more serious than in this country, for the purpose of constructing a non-arcing lightning arrester. Fig. 5 is a rough sketch of one form of this device. The inventor, Mr. A. J. Wurtz, made an exhaustive research* to ascertain which of the metals do and which

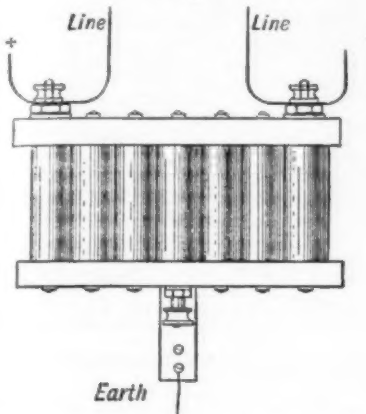
* Lectures delivered before the Society of Arts, London, 1895.—From the Journal of the Society.

* Dr. Sahulka, Zeitschrift fur Elektrotech., Nov., 1894; but see J. A. Fleming, "Electric Lamps and Electric Lighting" (Electrician Series), p. 155.

* See Electrical World, vol. xix, 1892, pp. 224 and 245.

do not arc. He found that nearly all metals will arc, excepting zinc, antimony, and bismuth. Take the case of an electric station, working on an arc lighting system, supplying 40 or 50 lights in series. There is employed a potential of 2,000 or 3,000 volts. If a lightning flash were to start an arc from the outgoing line to the incoming line, it would set up a most destructive arc. In order to prevent any such catastrophe happening, there must be provided a lightning arrester. But the lightning arrester might go on carrying the arc if it were not made of non-arcing material. This is Wurtz's invention: A cylinder, made of a particular sort of brass, with a high percentage of zinc in it, is connected to one line, while another cylinder is connected to the other line. Between them, nearly touching one another, is a row of intermediate cylinders. The middle cylinder in the row is put to earth.

FIG. 5.



Those on each side are not connected with anything at all, but merely fixed in a frame of stoneware, or some non-conducting material. Then, if either of those lines are struck by lightning, there will be a momentary spark across those cylinders in series; and the discharge will go down to the earth, instead of going to the power house and deranging the machinery, but it will not persist as a continuous arc; the discharge will splutter itself out instantly. It is not precisely known why this effect occurs with the metals and alloys named and not with others.

TEMPERATURE OF THE ARC.

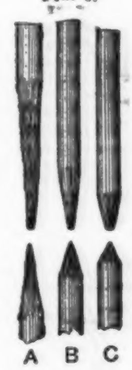
Until quite recently, the most wild guesses were all that could be learnt about temperature of the arc, or of its various parts; such numbers as 10,000° C. and 300,000° F. were quite common. Becquerel, in 1860, suggested 2,070° to 2,100° C. as the probable temperature of the arc between carbons, his source of current being a battery of 80 Bunsen cells. In 1879 Rossetti published a research, based on observations of the radiation, in which he came, not without some doubts, to the conclusion that the respective temperatures might be stated somewhat in the following terms: The temperature of the positive crater somewhere about 3,900° C., that of the negative peak about 3,150° C. He concluded that the arc itself, although it gave, being gaseous, less light, was actually hotter, and he suggested 4,000° C. as being the best guess available. Rossetti's value of 3,900° C. for the temperature of the crater has been re examined quite recently, in America by Nickolls, and in France by Violle. By two independent methods of measurement Violle arrived at numbers a little less, his final number at present being 3,500° C. He has arrived at this most recent measurement in a curiously direct way, viz., by a calorimetrical measurement. He arranged an arc in the following manner: The positive carbon was provided with a small end piece which at any moment could be knocked off and dropped into a calorimeter. This end piece was made the crater of the arc, and was allowed to burn away until it was quite thin; the supposition then being that it would nearly all be at the same temperature as its luminous surface. Then it was dropped off into the calorimeter, and the amount of heat it gave out in cooling was measured. The rather extravagant assumption had to be made, that the specific heat of carbon at this high temperature might be found by extrapolation from its known specific heat at lower temperatures; and the number arrived at agreed with the number derived from the observation of radiation. Mr. P. H. Gray has independently arrived at the value 3,400°. So we may attribute a fairly reasonable accuracy to Violle's number, 3,500°. We know that the lower carbon, the negative, is a good deal cooler. Violle's number for the negative carbon is about 2,700° C. He has recently brought forward evidence to show that the arc itself is probably hotter than either the positive or the negative carbon tip. That was previously a matter of inference from the nature of the radiations; spectro-photometrical observations being the basis. The new evidence is this: Make the arc, using not carbon, but a material which forms an arc at a lower temperature, zinc being the material in question. The temperature of the crater will, of course, correspond with the temperature of volatilization of the zinc. Now, if into the flame between the positive and negative zinc tips you use some material which is less volatile or less fusible than zinc, you can again, by the aid of the spectroscope, satisfy yourself whether it is hotter or not. Violle found that the arc between the zinc poles could raise a piece of carbon to a temperature distinctly higher than that of either the positive or negative sides; consequently, by inference, the flame in the carbon arc is hotter than either of the two tips. It is to be hoped that other physicists will work at this question. There is really a great deal to be done on that part of the physics of the arc. Still more recently Violle has returned to the question whether the intrinsic brightness of the crater is independent of the strength of the current. His latest announcement is that when he took a very large piece of carbon, and made arcs with as small a current as 10 amperes, and as large a current as 1,000, the intrinsic brightness of the crater surface, that is to say, the amount of light emitted per square millimeter of surface, was the same.

EFFECT OF CONDUCTIVITY OF CARBON PENCILS.

If the pencils of carbon used are of insufficient cross section, or of a badly conducting material, they will heat throughout their whole length, and waste an undue proportion of heat by offering a useless resistance to the current. From the point of view of economy a good conducting quality of carbon is to be preferred. But, apart from the question of economy, the matter is of importance. If a pencil of insufficient section, in proportion to the current it must carry, is used as the positive carbon, the crater cannot be properly formed, and the arc will be more or less unstable, while the flame will lick around the rim. On the other hand, if the pencil is too thick relatively to the current, the crater will be very deep, and again the arc will burn unsteadily, as the crater shifts its place from moment to moment. For a 10 ampere lamp one frequently finds the positive pencil to be an uncored carbon 9 or 10 mm. in diameter. If a carbon with a soft core is used, a slightly larger size is admissible. It is usual to employ for the lower negative pencil a carbon not cored, 1 or 2 mm. less in diameter than the upper positive carbon.

If the carbon is of such poor conductivity, or so thin, relatively to the current it has to carry, as to become red hot for more than a few millimeters beyond the luminous tip, it will waste by oxidation in the air and become coned for a considerable length. A pair of such carbons are depicted in Fig. 6 at A. It was long ago suggested that the conductivity of carbons might be improved by plating them with a film of conducting metal. At B and C, in Fig. 6, are shown

FIG. 6.



the forms assumed by carbons of the same quality when they have been coppered or nickeled. The current flows freely down the external metal skin without materially heating the pencils along their length. In the immediate neighborhood of the arc the metal is volatilized and disappears. Coppering is now seldom resorted to, as the carbon pencils of modern manufacture are of higher conductivity, and do not require to be coated. The conductivity of good moulded carbon pencils, such as are now used, is from 15 to 20 times as great as that of pencils sawn out of gas retort carbon, being only from $\frac{1}{10}$ to $\frac{1}{5}$ ohm per foot of length. But coppering would reduce these values ten or twenty fold.

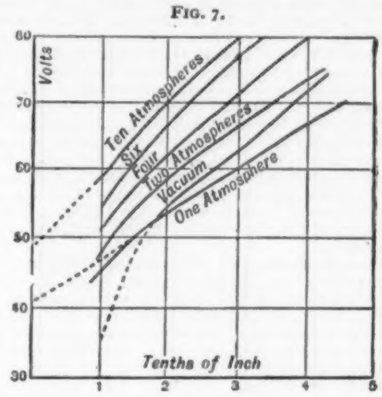
EFFECT OF SURROUNDING GASES ON THE ARC.

Another matter that has received extremely little attention is the effect on the arc of the surrounding medium. Until recently it was not known what would be the effect of increasing the pressure of the air or of surrounding the arc by different materials instead of atmospheric air. At a time before this 39 volts of back electromotive force was as well recognized as it is now, it was supposed that this constant part of the voltage had something to do with the surrounding air; that, in fact, it was due to the oxygen and carbon combining. In order to disprove this notion, I had some experiments made* three or four years ago, with arcs burning in different materials, in chlorine, in coal gas, in hydrogen, in nitrogen, etc. I found that it did not make one volt difference what the surrounding gas was. The 39 volts were still required as the minimum electromotive force for a steady arc. Incidentally I observed that the shape of the positive crater and of the negative peak is quite different and differs in different gases. In coal gas one finds that the hydrocarbon becomes deposited in the form of a mantle all around the crater, so that the negative peak penetrates up into a sort of chimney of deposited carbon. When one works at reduced pressures one begins to get into the vacuum tube order of phenomena. The arc may be drawn out to a great length and expands in size; but the luminosity of the tips of the carbons diminishes and the phenomenon of the crater changes. Very little carbon is volatilized and the electromotive force required to sustain the discharge is lessened.

When, however, one increases the pressure, one meets with arc phenomena that are slightly different from those at atmospheric pressure. Here we have the justification of the view that the 39 volts is due to the work done in the vaporizing of the carbon. So far as I know, much the most complete experiments yet made on this point are those made in America by Dr. Louis Duncan† and some of his students. Figs. 7 and 8 embody in diagrammatic form the principal results of the researches.

Duncan caused the arc to be made in a vessel into which the air could be pumped or from which it could be exhausted. Take first the case of the arc made at the ordinary pressure of one atmosphere. The sloping line marked "one atmosphere" in Fig. 7 here shows the connection between the volts and the length of the arc; the lengths in successive experiments being plotted out horizontally in $\frac{1}{10}$ of an inch. We have in general the same sort of sloping things as previous experimenters have found. But the lines that correspond to different pressures all slope down from right to left. They are not all straight, though straight over a considerable range. The "one atmosphere" line is not quite straight, for it begins to turn down when the length is small. But its straight part points toward 40 or 39, according to the current that is being employed. Now if my theory is true, that the arc temperature is that at which carbon is vaporized, it follows that if you put on the pressure you ought to have exactly the same sort of effect as happens in boiling liquid when you put on pressure; you raise the temperature of boiling. In the present case you raise the temperature of evaporation and require more energy to make it boil; that is to say, it will boil,

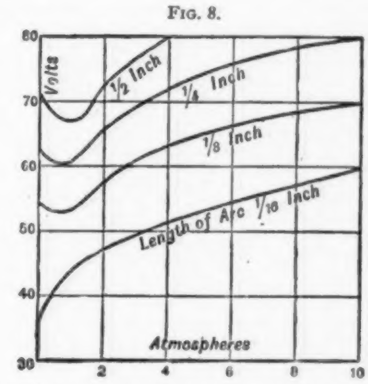
FIG. 7.



other things being equal, with a bigger back electromotive force.

The diagram shows the line for 2 atmospheres, for 4, for 6, and for 10. Let us pass at once to the last as being the extreme case. The "ten atmospheres" curve points back to 48 volts instead of 39, proving, in fact, that more work is done by the current in going through the arc when it is made more difficult for the carbon to evaporate from the crater into the arc itself. There are some other things which might be noticed in this figure. For instance, when working in a vacuum, short arcs require less electromotive force and long arcs a greater than is required in air at the ordinary pressure. The next diagram, Fig. 8, is also one of Duncan's, plotted out in a different way. Here he is employing a constant length of arc, but varying the pressure. As you increase the pressure from vacuum first to 1 atmosphere, then to 2 atmospheres, and so on, you notice what happens. With a very short arc there is a continuous increase in the volts required, but if the arc is ½ inch long, and you pass from vacuum to 1 atmosphere, you want fewer volts. It is easier to send an arc through air than through vacuum when it is only ⅛ inch long, but after that the electric pressure required increases. Suppose you begin with a ⅛ inch arc, there is a very distinct lowering of the voltage, but a little over 5 per cent. in amount. Yet, on raising the pressure above 1 atmosphere, the voltage again increases. All this points to something not yet discovered.

FIG. 8.



Now, let us try to sum up what is known on this point. Carbon, the most refractory of known substances, has a definite temperature of volatilization when the pressure is kept constant. Change of pressure will change that temperature. However intense the heating effect of the current, however fiercely we pour in energy by means of the electric circuit, we cannot raise the free surface where the carbon is evaporating above that limiting temperature. Increasing the rate at which heat is poured in will simply increase the rate of evaporation. Further, carbon is found at these elevated temperatures to have chemical properties of the most active kind. No known compound exists that is not dissociated at arc temperatures. Put any of the most refractory substances known—lime, magnesia, alumina, asbestos—into the arc, they are dissipated, reduced, volatilized; mix any of them with the carbon, and one finds that, without exception, the effect of their presence is to reduce the temperature, to lower the degree of luminosity, and, what is more significant, to lower the apparent back electromotive force. Increase of pressure, however, raises the temperature and raises the luminosity. What a glimpse this gives us of the possible state of things going on at the surface of the sun! For some reason—into which I need not enter—the temperature at the sun's surface is very high, higher, to judge by the radiation, than that of the crater of the arc. Also, the pressure of the solar atmosphere, at the level of the sun's surface, must be much higher than the one atmosphere of our air. At such temperatures (and pressures) all known chemical compounds would be dissociated into their elements, and all the known elements would be volatilized. The last element to be volatilized would be carbon. Are we not justified, then, in hazarding the suggestion that the luminous surface of

* See Electrician, xxix, p. 460.

† L. Duncan, A. J. Rowland and C. Todd. See Electrician, xxxi, p. 360.

the sun, to which it owes its brightness, is in reality a surface of incandescent carbon? If not, what else can it be?

[Remarks since added, October, 1895.—It is only just to add, in view of later researches, that there is some evidence not concordant with the views put forth in this lecture in January. Experiments made in Ireland by Mr. W. E. Wilson* go to show that under certain conditions the light given out by an arc lamp is reduced in brilliancy when the lamp is burned under a pressure of several atmospheres. Mr. Wilson considers that he has shown that the intrinsic luminosity is lowered. If this should be established, it will of course mean that the temperature also is lowered by pressure, and that, therefore, the temperature of the arc cannot be considered as dependent upon the temperature of volatilization of carbon. But it remains to be proved whether the temperature of volatilization of carbon is so lowered by pressure. The matter is complicated by the circumstance alluded to in the lecture, that the melting point of carbon is so close to its boiling point. In the absence of any knowledge as to whether at the fusion point any change of volume occurs, and whether such change be an expansion or a contraction, it is impossible to say whether increase of temperature will raise or lower the melting point. All one can say is that the question raised is still in suspense, and that for the present Mr. Wilson's observations are distinctly against the theory put forward.

Further, in September, 1895, at the meeting of the British Association, Professor Ayrton and Mr. Mather communicated a paper on the apparent back electromotive force of the arc, which they had been examining by a new method of electrical measurement. This method cannot be discussed here, but there are grave doubts as to its validity. Using this method, the extraordinary result was obtained that the supposed back electromotive force is a negative quantity, that is to say, instead of an electromotive force opposing the current, they found a forward electromotive force helping it. If this were true it would involve the admission that the arc would be acting as a source of electric power, and it would also involve the admission that the resistance of the column of vapor of the arc is greater than can be accounted for by the fall of potential per unit of length, both of which conclusions would be inadmissible.—S. P. T.]

RESEARCHES OF PROF. AYRTON.

Any account of the physics of the arc would be incomplete which did not include a reference to the researches of Professor Ayrton. I listened, when at the Electrical Congress at Chicago in 1893, with the utmost delight to a very elaborate paper, which cleared up a number of doubtful points, and gave us far more complete details about the phenomena of the arc than anything hitherto available. The same sort of observations had been made by Professor Ayrton, and by Mrs. Ayrton, as those which I and other observers had made in time past. They had been carefully comparing the length of the arc, the voltage, the current, size of crater, and so forth, but over very much larger ranges, and with more perfect appliances than any previous observer. In particular, they had found that if after adjusting any of the conditions as to length, current, and the like, a sufficiently long time (exceeding half an hour, if I remember aright) were allowed to elapse, the crater and peak settled down to a special form corresponding to those conditions. And that to every change of length or of current there corresponded a different form. Only when each separate experiment—and there were hundreds of them—had been carried on for a sufficient length of time could readings of voltage be obtained which were truly normal. Results obtained in this patient way, when plotted out in curves, showed the most surprising regularity. Instead of the broken curves (such as Frölich's, Fig. 2 supra) of the earlier observers, curves of smooth outline were obtained. Also the observations had been pushed further. The curves had been carried to extremes—for very large currents, and very small currents; to very high voltage, and very low voltage; with very short arcs, and very long arcs; with very big craters, and little craters.

Those curves contained by far the most complete account of the natural history of the arc than any other thing attempted by any one else. I looked forward to the publication of these results with great interest. Sad to relate, the scientific man to whom Professor Ayrton intrusted the paper before he left America to return home, after keeping them beside him for some months without sending them to press, allowed his negro servant to use them for lighting fires. Only a few fragmentary notes remain. I have urged Professor Ayrton to renew his labors and repeat investigations of such importance, and I am glad to say that we are likely to have something soon from him to repair the loss. But until that appears I shall feel, at any rate, as though a very large part of the physics of the arc was still wanting.

[Note added, October, 1895.—During the course of the current year, Mrs. Ayrton has communicated to the Electrician a series of papers embodying the fragments of the research of which the records were so shamefully treated, together with the results of renewed experiments. Mrs. Ayrton has further communicated to the British Association, in September, 1895, a paper on the formulæ for expressing the relation between voltage, current, and length of arc. The results of these observations are so important that it would be an injustice to their merits to attempt to summarize them here. Mrs. Ayrton's formula has been added to those exhibited in the table on page 949.—S. P. T.]

ARC FURNACES.

From the time of De la Rive and of Despretz, experiments have been made on the use of the arc for electrometallurgical processes, owing to its very high temperature and the reducing action of carbon. Napier, in 1845,† presented to the Society of Arts an electric furnace intended for the reduction or metals, consisting of a lined plumbago crucible, into which a carbon electrode was introduced. Sir W. Siemens was among the first to revive the construction (Fig. 9) of an arc furnace. He introduced, through the sides of a crucible of refractory and non-conducting material, two pencils of carbon, between which the arc was formed. Since then great progress has been made by Cowles in the production of aluminum alloys, and by Moissan and others in the reduction of metals. A wide field for commercial development has thereby been opened.

Another thing has to be done; the chemists must go to work. The chemistry of carbon at high temperatures is one of those things that ought really, now that the supply of electricity is so common, to be easy to experiment upon. The electrician provides what the chemist wants, the means of making a high temperature with an arc. What the chemist has not yet worked out is the chemistry of carbon at high temperatures. Thus, we know that chemists have not found a compound yet that cannot be decomposed into its elements at the temperature of the arc in the

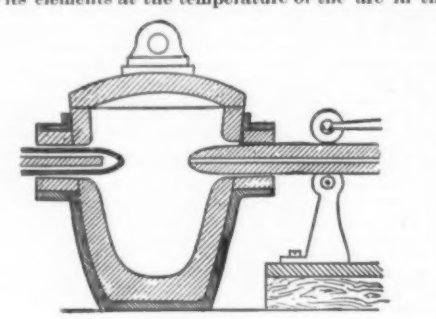


FIG. 9.

presence of carbon, so that carbon appears to be the nearest approach yet to the universal solvent. When I deal next week with the optics of the arc I shall recur to this matter of the behavior of carbon itself: but from this point onward—that is to say, in my next lecture and in the one afterward—I do not propose to return to any of the other materials that have been proposed. It simply is waste of time at present to deal with arcs made with any other material than carbon; in fact, I will take this one of the 70 known elements, and confine myself to it. And I will deal with that element in a particular way, viz., as used in the making of an arc at about 40 to 50 volts, leaving aside all high voltage phenomena, all vacuum phenomena, all the abnormal phenomena of the arc, confining myself to the arc as we know it for industrial purposes.

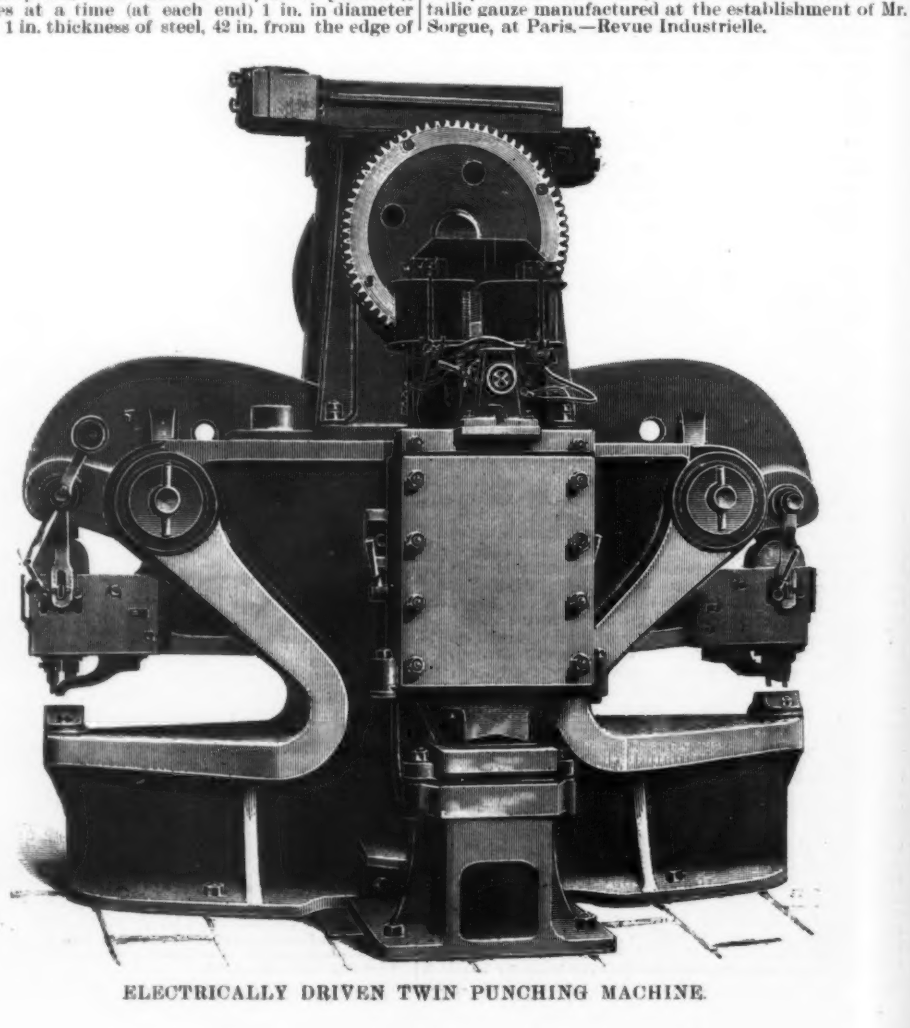
* Proc. Roy. Soc., May 30, 1895, or see the Electrician, June 21, 1895 p. 261.

† See Mechanics' Magazine, 1845, p 432.

ELECTRICALLY DRIVEN TWIN PUNCHING MACHINE.

THE engraving, for which we are indebted to Engineering, illustrates a very powerful punching machine of the cam lever type, driven by an electric motor. The machine is arranged at each end to punch two holes at a time, but as each punch is provided with an independent stop motion, either may be thrown out of action instantly. This arrangement is found advantageous when a plate has to be punched with more than one diameter of holes; as the required diameter of punches can be fixed in the machine before starting to punch, and the plate can be punched without interruption. The machine is equal to punching two holes at a time (at each end) 1 in. in diameter through 1 in. thickness of steel, 42 in. from the edge of the plate; or one hole of 1¼ in. diameter through 1¼ in. thickness of steel. It is arranged with side cutter to cut the notches in stringer plates up to 10 in. by 8 in. through ⅞ in. thickness.

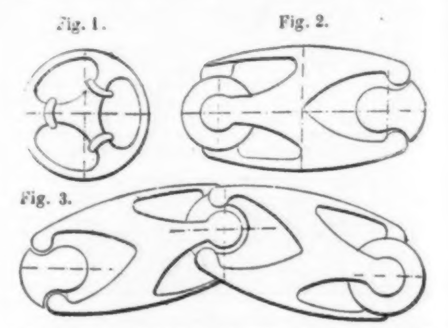
The motor driving the machine is of 18 brake horse power and runs at a speed of 700 revolutions per minute. The cam shaft and all gearing are of steel, except the large wheel on the cam shaft. The machine has brackets arranged for carrying two cranes. Messrs Craig & Donald are the makers of this machine.



ELECTRICALLY DRIVEN TWIN PUNCHING MACHINE.

FLEXIBLE SHAFT WITH BALL JOINTS.

THE use of balls in mechanical constructions continues to increase, and we have recently had an opportunity of seeing a new application of them of a most interesting character.



FLEXIBLE SHAFT WITH BALL JOINTS.

Pursuing the study of the arrangements applicable to the manufacture of flexible shafts for the transmission of rotary motion, Messrs. Marotte & Company, who have already made themselves prominent by the invention of a shaft of this kind, have conceived the ingenious idea of connecting the links of a flexible chain shaft by means of a joint consisting of a ball.

It will be seen from the accompanying figures that at the extremity of each element there is formed a hemispherical concave seat surrounded by claws. Upon interposing a ball between two consecutive links, and then slightly incurving the extremities of the jaws with a hammer, there is quickly formed a flexible shaft possessing a surprising facility of curvature. In order to give this chain the rigidity necessary for the transmission of motion, it is introduced into an elastic sheath formed of a thin and narrow strip of steel wound spirally.

Comparative experiments have proved the very great influence of the balls upon the reduction of friction between the links and this sheath. So it appears warrantable to count upon a smaller diameter of the shaft for an equal amount of energy transmitted and, consequently, upon a saving in power.

There is nothing absolute about the form of the links. The inventors are studying a new one that will afford greater lightness without prejudice to the strength.

A beautiful aspect is given to this shaft by concealing the spirals of the envelope under an ornamented metallic gauze manufactured at the establishment of Mr. Sorgue, at Paris.—Revue Industrielle.

TRIPLE EXPANSION ENGINE—FRIKART'S SYSTEM.

WE illustrate from the Engineer a triple expansion engine, which was not long ago exhibited by Messrs. John Cockerhill & Company at the Antwerp Exhibition. In no country has the rotary valve, which is the main feature of the Corliss system, found more favor than in Belgium. All the large horizontal engines exhibited at Antwerp have valves of the Corliss type, though each manufacturer has a different method for regulating the admisson and cut-off which he considers superior to that adopted by rival makers. In Messrs. Cockerill's engines the system used is called the Frikart. They have for some time made single cylinder engines on this principle and exhibit one of 100 indicated horse power, with cylinder 1 ft. 7¾ in. diameter and 3 ft. 5¼ in. stroke. This machine is used to drive a dynamo, and works very steadily under a varying load. The application of the Frikart valve to triple expansion engines is quite new, and the one exhibited at Antwerp is the first that has been made. It works at a pressure of 150 lb., and its principal dimensions are: Diameter of high pressure cylinder, 1 ft. 3¾ in.; intermediate, 1 ft. 11⅝ in.; and low pressure, 3 ft. 1⅜ in. The length of stroke is 3 ft. 11¼ in., and the number of revolutions is eighty.

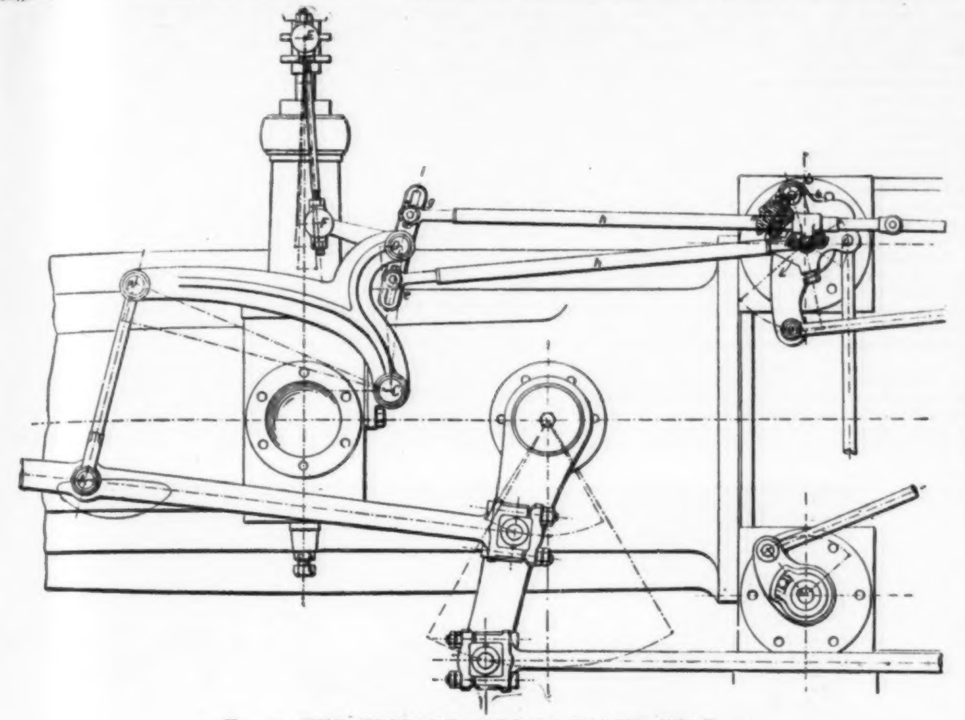


FIG. 2.—THE FRIKART-CORLISS VALVE GEAR.

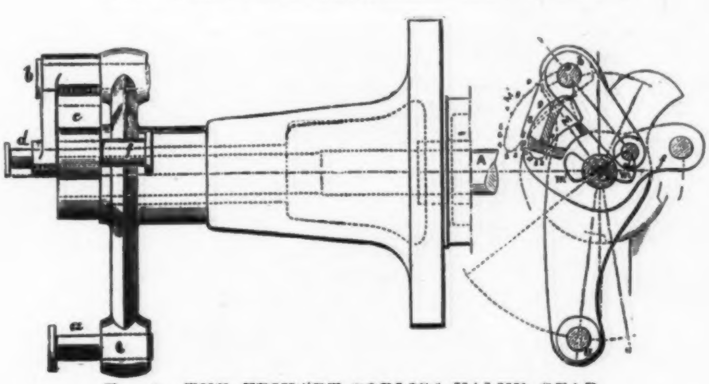


FIG. 3.—THE FRIKART-CORLISS VALVE GEAR.

The chief characteristic of the Frikart valve is that by it any degree of cut-off from 0 to 75 per cent., or even more if necessary, can be obtained with a single eccentric, as the governor completely controls the admission. It is of the highest importance to be able to prolong the admissi on, as by this means the power of the machine to deal with extreme cases is greatly augmented. For instance, it may be required to exert increased oower, or the pressure in the boiler may fall, either accidentally or because the fires are being allowed to burn down before stopping the works. If, as in many machines, when the admission of steam extends over more than four-tenths of the stroke, the cut-off only takes place toward the end, this sudden increase in the admission will necessarily make a considerable, and possibly prejudicial, change in the speed. An arrangement by which the admission can be regulated so as to take place through any proportion of the entire length of the stroke is especially advantageous for compound and triple expansion engines, where there may be a large amount of steam admitted into each cylinder.

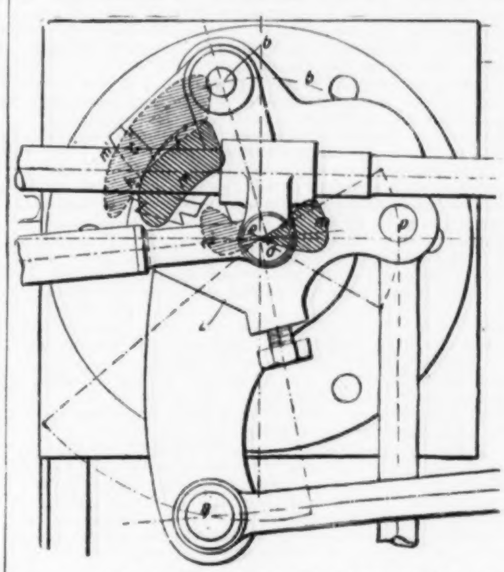


FIG. 4.—ENLARGED VIEW OF PART OF FIG. 2.

In the illustrations, Figs. 2, 3, and 4 show different parts of the back admission valve gear. The piston being at the back dead point, the cast iron cut-off lever, a b, is in the position shown. This lever works freely on the axle of the admission valve, and carries the part of the trip gear which the makers call the "active." This is in steel, and consists of a finger, b c, and a lever, b d. The "passive" part consists of a lever, L, keyed to the end of the valve axle, and con-

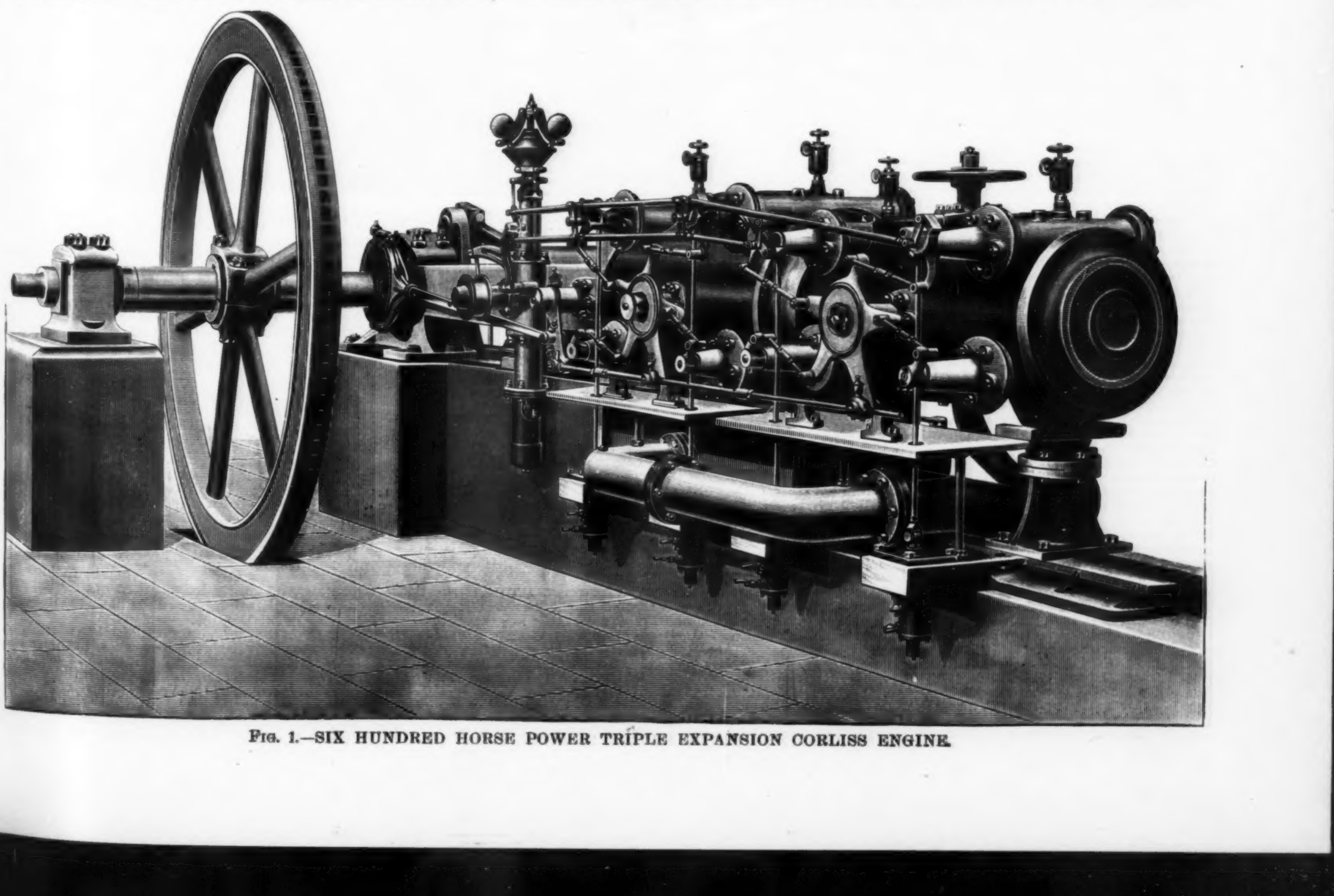


FIG. 1.—SIX HUNDRED HORSE POWER TRIPLE EXPANSION CORLISS ENGINE.

nected by a jointed rod to the piston of a dash pot. The finger, b c, has a tempered steel trigger, c, bearing on the trigger plate, k—also in tempered steel—of the lever, L; the piston being always supposed at the back dead point.

In this position the edges of the back admission valve, and of the orifice, are just touching. The radius to which the trigger plate, k, is curved being equal to the length of the finger, b c, the lead is constant. On leaving the described position, the admission valve will commence to open, and the orifice will be more and more uncovered. But the finger, c, moves with the small lever, b d; and during the oscillation of the point, b, the point, d, which is connected by levers with the eccentric rod, will move also, and will follow the curve, m; consequently the edge of the trigger, c, will describe the curve, M. If, therefore, from the center, O, we strike an arc, passing through the edge of the trigger plate, k, the point where this arc cuts the curve, M, will be that at which the release takes place. At this moment the air piston, connected with the valve gear at the point, p, brings the whole apparatus back immediately into its original position.

The points 0 to 19 on the curves, m and M, and on the arcs, a and b, correspond to a complete revolution of the crank shaft; so that it will be seen that in its present position the release takes place at about 0·70 of the back stroke of the piston.

The manner in which the action of the eccentric rod causes the point, d, to describe the curve, m, is as follows: The point, A, of the eccentric rod describes a sort of ellipse; its vertical movement is transmitted to the regulating lever, B C D, oscillating at C; at the point, D, is connected a lever with three arms, e f g, of which the arm, f, is joined by a small connecting rod to the sleeve of the governor. Let us suppose for a moment that this sleeve is fixed, and in its lowest position; the point, f, will then describe a small arc round it, and the two extremities, e and g, will move in the same manner as the point, D. It is this horizontal movement which, transmitted to the points, d, by the rods, h h, and combined with the circular movement round the pivot, b, causes the curve, m, to be described.

If the sleeve of the governor be raised to its highest position, the point f will be raised also, and the points, e and g, will undergo a corresponding angular movement round D, while continuing to follow the horizontal movements of the same point, the consequence being that the point, d, will now describe the dotted curve m^1, and the edge of the finger c will describe the dotted curve, M^1. The point 10 of this latter curve is exactly at the extremity of the trigger plate. The trip would therefore take place at the dead point.

For an intermediate position of the sleeve, the point, d, will describe an intermediate curve between m and m^1, and the finger c will describe a curve between M and M^1; and thus, by the action of the governor, the admission will vary from 0 to 0·70. The admission of steam to the low pressure cylinder is fixed and regulated by hand; the cut-off of the low pressure is therefore constant.

Fig. 1 is from a photograph showing the high pressure and intermediate cylinders, which are arranged as in a tandem engine. The low pressure cylinder drives a crank on the opposite side of the flywheel from the other two. The condenser and air pump are behind the low pressure cylinder, and in a line with it. All three cylinders are steam jacketed; the steam for the jacket of the high pressure cylinder is direct from the boiler, that for the intermediate from the reservoir or steam chest between it and the high pressure, and that for the low pressure cylinder from the other reservoir between the intermediate and low pressure cylinders. These two steam reservoirs are under the floor, and the water which condenses in the jackets is drawn off by three separate pumps, and returned to the boiler. The engine has been designed for an effective horse power of 600.

SNOW SHED FIRE PROTECTION.

THAT portion of the Southern Pacific Railroad lying between Blue Canon and Truckee (Central Pacific division), a distance of 41 miles, says the Railway Review, is thickly studded with an extensive system of snow sheds costing nearly, if not quite, one and one-half million dollars. During the winter months these sheds are protected from fire by the snow, but in the summer they become very dry and are readily ignited. A spark from a passing engine or a forest fire, or a match lit by a malicious tramp, may do great damage, not only costing thousands of dollars, for repairs, but blocking the road with debris, so that all trains are stopped for several days at a time. Several years ago the railroad company reduced the danger of fires being set by tramps by issuing orders to trainmen to let those gentry of the road ride through the sheds whenever they boarded a freight train, and under no consideration to put them off until the sheds were passed, but other dangers threaten which do not offer so easy a remedy. In spite of spark arresters on the locomotives, sparks will rise. Nor does there seem to be any way to keep the camper from breaking camp and leaving his fire burning behind him.

When from these or any other cause a fire does start in the sheds immediate action is imperative. Built as they are they form a sort of funnel through which the air rushes with great force, and this draught is increased when a fire starts. The result is that the structure is consumed with tremendous rapidity, and stories are told of instances where a man could not run fast enough to keep ahead of the roaring flames. Then woe to him if the fire is behind him and he does not succeed in finding an opening through which he can crawl to the outer world.

All of these dangers have been reduced to a minimum, says a writer in the San Francisco Chronicle. The necessities of the occasion demanded a remedy, and this has been found in a system of fire alarms, patrols and fire trains that probably surpasses anything of the kind in the world. Situated a distance of a mile apart throughout the entire length of shed-guarded track are placed unlocked electrical call boxes similar to those in use in the cities. On the face of these are inscribed the words: "East—west—rock on track—shed down—train wreck—car off slide—fire." Besides these there are 34 fire alarm boxes, which are kept locked. These are used exclusively for fire. When an alarm is rung in one of these a gong strikes the number of the box in Sacramento, 100 miles away, and on the different points where the fire trains are situated.

The forty miles of sheds are constantly patrolled by men selected for that purpose. Each man's beat is less than three miles long, and is so arranged that he passes over it a short time in advance of every train. The most important of all, however, are the duties performed by the fire trains, of which there are three. These trains consist of an engine and tender and two flat cars, upon which are mounted immense boilers filled with water. These boilers are decked to afford room for the crew when at work on a fire The regular crew consists of three men—the engineer, fireman and brakeman. But when an alarm is rung this is enhanced by picking up the nearest section gang. Of these fire trains one is stationed at Blue Canon, another at Summit, and a third at Truckee.

Whenever a patrolman discovers a fire in a shed, he hurries to the nearest box and turns in the alarm. Instantly the number is sounded on a huge gong in Sacramento and at fire train stations. The crew of the fire train nearest the point of danger spring to their places and await orders from Sacramento. At the latter place the train dispatcher seizes his key and sends his orders along the road to side track all trains. A few minutes pass and the word comes flying over the wire that the last train is out of the way. The dispatcher then strikes the key again, and the fire train

THE PORTAL AT THE ENTRANCE TO THE NEW BRIDGE ACROSS THE DANUBE.

receives the word "track clear; box 28; go." The engineer seizes the throttle, the fire train moves out on the main track and starts for the scene where it is to do battle.

The nerves of every man in the crew are strung to the highest tension, for these men well understand that they are about to make a run at the rate of 60 miles an hour down the side of the mountain and around curves so abrupt that it seems almost impossible that the engine can stick to the rails. As the train gathers headway the engineer begins an incessant blowing of the big chime whistle with which the engine is mounted, and whose sound is familiar to every railroad man in the mountains. At the first sound of this whistle every one within hearing springs from the track and hugs the side of the shed, for he knows that in a few moments the train will bound past him like a cannon ball.

When the scene of a fire is reached the train is stationed as near as possible to the burning timbers, and the battle begins. The method pursued is the same as is used by the city fire departments. Two streams of water are thrown against the flames, and it is rare that the fire is not under control in less than twenty minutes. If the wind is against them the engineer must be careful not to let his train get too close, and the ax and pickax men who toss aside the burning timbers must look alive that the weakened sheds do not fall upon them.

During the intervals between fires in the summer the trains are used in wetting down the sheds so as to reduce as far as possible the chances of their being ignited by sparks from passing engines. For this purpose the fire trains are rigged with spray nozzles, which completely deluge the interior of the sheds as they steam slowly through them. This wetting down is done two or three times a week through the hottest months.

Near Cisco is one of the highest mountain ridges on the western slopes of the Sierra. On the topmost point of this ridge, at an altitude of nearly 8,000 ft., there is a little cabin in which a man, his wife and a boy live from the time when the snow first begins to disappear in the spring of the year until it reappears in the autumn. The man and the boy from the point of observation which they occupy can see 35 miles of snow sheds. They can also see the entire stretch of mountain and valley country from Mount Lyell, in the Yosemite Valley away in the south, to Mount Shasta, 200 miles to the north. They can see the lights of a dozen cities, the canons or valleys of as many rivers and 37 mountain lakes, but it is for the purpose of watching the sheds that they occupy the place which they do. The trackwalkers, hemmed in as they are by the sheds, cannot see the fires which may threaten the structure from the outside, and this is the reason that the little cabin was built on the top of that mountain.

Day and night, no matter how stormy the weather, this man and boy keep their vigil, and at the slightest sign of fire threatening the sheds a telephone message locating it is immediately sent to Cisco, from which place orders are issued to have it extinguished. These fires are located from Red Top, the name by which the site of the little cabin is known, by means of a dial, in the center of which an arrow swings like the needle of a compass. The point of the arrow is directed toward the fire, which causes the feather end to cover a marking on the dial indicating the name or number of the place toward which the arrow points.

THE NEW BRIDGE ACROSS THE DANUBE AT CHERNAVODA.

ROUMANIA has, to a certain extent, been recompensed for the loss of Bessarabia by the connection of the network of railroads on the left of the Danube with a good harbor on the Black Sea by means of the railroad bridge between Futesti and Chernavoda. This bridge, which was opened to traffic on September 26, 1895, in the presence of the king, the heads of the civil and military departments, the diplomatic corps and an immense concourse of people, connects Bucharest with the rising port of Kustendji, thereby making the Roumanian trade quite independent of any political or commercial disturbances in neighboring states or of the freezing of the Danube.

The work on this bridge was undertaken at the personal instigation of King Charles, whose first idea was to connect the oldest Roumanian railroad, the one extending from Bucharest to Giurgevo, with the Turkish road from Rustchuk to Varna, thus connecting Roumania with a harbor on the Black Sea that would accommodate the largest vessels. The undeveloped condition of both sides of the lower Danube at that time

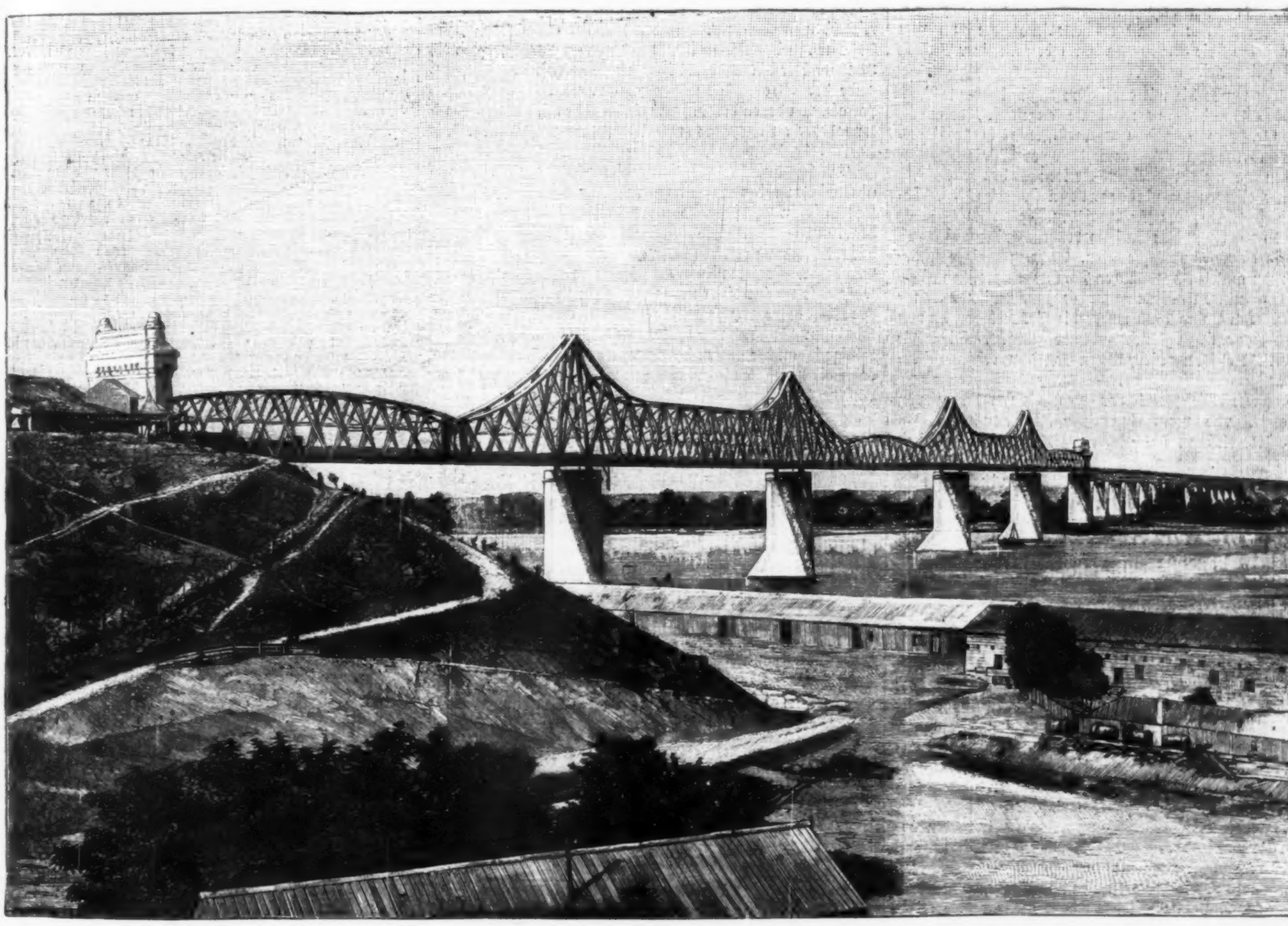
delayed the execution of the plan, which was, however, revived in a new form when Dobrudscha was made a part of Roumania in 1878 by the Treaty of Berlin.

The Chernavoda-Kustendji Railroad, which had been built with English capital, was bought by the state, then the Bucharest-Futesti road was taken in hand, and finally, on August 3, 1882, the Department of Public Works offered a prize for the best designs for an iron railroad bridge between Futesti and Chernavoda. Saligny, Inspector General of Bridges and Roads in Roumania, was successful in the competition. Saligny belongs to one of the French families which have become naturalized citizens of Roumania, and received his technical education in the Polytechnic School of Berlin. The bridge was begun in 1890 and finished in September, 1895. It is the largest iron railroad bridge on the Continent of Europe.

The entire length of this immense structure is something more than 17 miles, and it cost about $6,500,000. The nature of the ground was such as to present the greatest difficulties; in many places the banks of the river are exceedingly steep, and at Chernavoda reach a height of from 100 ft. to 130 ft.; and between the main branch of the Danube on the east and the tributary, the Borcea, on the west, stretches a swampy region three or four miles wide, which is flooded at high water. The iron bridge across the Borcea is supported on two immense stone piers 65 ft. 7 in. above the lowest water mark, and is 3,225 ft. 8 in. long. Each of the three spans is 459 ft. long. On the Balta, or flooded ground, and next to this bridge, is a masonry embankment that is broken by 24 openings, each having a span of 140 ft. 5 in. long, and serving as an outlet for the water at times of flood. A viaduct 2,994 ft. long leads from this embankment to the bridge across the Danube proper. Each of the openings in this viaduct has a span of 199 ft. 7 in. and the slender stone pillars are 114 ft. 9. in. high.

The bridge over the Danube is provided with four immense piers in the river, forming five spans, the two on each side being 465 ft. long, while the central span is 623 ft. long; this is the longest span in any bridge in Europe. The iron trusses above the river piers are 105 ft. nigh, making with the latter a total height of 328 ft. These piers extend from 59 ft. to 62 ft. below the bed of the river, forming thus the foundation. At low water 190 ft. of the piers is exposed above the water level and at high water about 101 ft. The ends of the bridge are crowned by two portals 65 ft. 7 in. high, the one on the left bank being decorated by bronze medallions of the king and queen, and the inscription, "Brücke König Karl's I" (Bridge of King Charles I).

The bridge across the Danube at Chernavoda makes Russia independent of the river, which is seldom free from ice during the winter, and secures an outlet for trade through the good harbor at Kustendji, which is always open and the use of which can never be interfered with by the political measures of the neighboring powers; and at the same time this new road will bring no small portion of the trade between Europe and the Orient to the railroads of Roumania and the harbor of Kustendji, because this is the shortest line between the northern seas and the countries of the East. Doubtless Dobrudscha will now be settled by a steady agricultural people, being changed by the new road, as the road between Bucharest and Futesti has changed the barren, sparsely populated steppe of Baraganu into cultivated land.—Illustrirte Zeitung.



THE NEW ROUMANIAN BRIDGE ACROSS THE DANUBE AT CHERNAVODA.—FROM A PHOTOGRAPH TAKEN BY H. WICHMANN, OF GALATZ.

THE CATASTROPHE OF BOUZEY.

THE commission appointed to inquire into the causes of the catastrophe of Bouzey* has just presented its report to the Minister of Public Works. It is very voluminous, and, beginning with a complete history of the successive phases of the project, afterward recalls all the details of the catastrophe of April 23, 1895, and finally draws the following conclusions:

1. The masonry of the Bouzey dam was exposed to tractive stresses that exceeded its power of resistance, because of the want of adhesion of the work executed in 1880 to that finished the preceding season. In consequence of such want of adhesion, there was produced, under the action of a tractive stress of 0 565 kilogramme, on an average, and of 1 13 kilogramme at a maximum, a long horizontal fissure at the point of underpinning of the masonry, and it was the subpressure, caused by the oblique fissure of point 243 (which was due to the displacement of 1884) and by the long horizontal fissure, that led to the undermining of the work.

2. The catastrophe of Bouzey shows that it is necessary to arrange the walls of reservoirs in such a way that the masonry shall not be exposed to any tractive stress.

3. In case an accident similar to that which happened to the Bouzey dam in 1884 should occur in other works, there should no hesitation in entirely reconstructing those portions of the masonry in which there may be a suspicion of the presence of fissures capable of causing sub-pressures.

4. It is expedient to proceed to a verification of the conditions of stability of the existing masonry dams, and, if necessary, to reduce the level of the reservoirs that they command, so as to suppress therein all tractive work.

The Council General of Bridges, in indorsing the conclusions of the report, expresses the opinion that the principal causes of the disaster of April 27, 1895, were due to the raising of the dam and reservoir two meters, contrary to the council's advice given in 1880, joined to the existence of fissures that had occurred previously, and especially of the horizontal one, apparently due to a want of cohesion between the masonry of 1879 and that of 1880.

The commission makes no reference in its report to another primordial vice to which allusion has already been made several times, says Le Genie Civil, and that is the character of the ground upon which the foundation of the dam was constructed. A geological section of the Bouzey valley shows the following formation: A stratum of peat on a level with the surface, to which succeed alluvium, sand and gravel, and then a bank of schistose sandstone, new red sandstone full of fissures, and finally compact new red sandstone. The new red sandstone, which was taken as the foundation for the work, is very porous and but slightly cohesive, as was shown by the tests for strength. The true compact rock is not found until a depth of from 8 to 6 meters upon the right bank, of more than 10 meters in the channel, and of 17 upon the left bank is reached. It will be understood that the engineers shrunk before the expense necessary to excavate for rock at such a depth, but, after the warning of 1882, they should no longer have had any hesitation, and, as with the Gros Bois dam, which supplies the Bourgogne canal, should have supported the outside facing upon solid rock.

* See SCIENTIFIC AMERICAN SUPPLEMENT, No. 1024, p. 16[illegible].

H. M. S. JUPITER.

H. M. S. JUPITER, which was launched by Messrs. James & George Thomson, Limited, Clydebank, on November 18, is a first class battleship of the Majestic class. The dimensions are: Length, between perpendiculars, 390 ft.; breadth, extreme, 75 ft. 9 in.; depth, moulded, from upper deck, 44 ft. 9 in.; mean draught, 27 ft. 6 in.; displacement, 14,900 tons. The protection consists of an armor belt of Harveyed steel 9 in. in thickness, which extends for 215 ft. At the ends are transverse armor bulkheads, also of Harveyed armor, which below are 12 in. in thickness and above 9 in.; and in addition there is a protective deck of from 3 in. to 4 in. in thickness extending from end to end of the ship. This deck is arched and is intended to protect the magazines and machinery from fragments of shells and falling shots.

At the bottom the belt, which extends up to the main deck, and is about 15 ft. broad, is 5½ ft. below the water line, and before and after the belt the protective deck is at a lower level than amidships, so that the ends of the ship are protected by an under-water steel deck. The hull of the vessel has been coated with Hartmann's Rahtjen's composition. The heavy guns are four in number, and each is of 46 tons weight and 12 in. caliber. They will be mounted in pairs in redoubts of Harveyed armor, 14 in. thick, above the main deck and 7 in. thick below, extending from the protective to a few feet above the upper deck. The freeboard of the ship is exceptionally great, the center guns being about 27 ft. above the water line.

The secondary armament consists of 12 6 in. quick firing guns, all of which are mounted in armored casemates on the main and upper decks, which afford protection to the crews working the guns from the enemy's quick firing shot and shell. There are also a number of small quick firing and machine guns, and 5 in. torpedo tubes. Four of the latter are in submerged compartments, so that as the torpedoes are discharged below water there is no danger of them being exploded before being fired by an enemy's shells. The other tube is fitted at the stern on the main deck and is protected by an armored mantlet.

The ammunition is worked in a passage underneath the protective deck. From this passage are armored tubes to the various guns, and by means of hoists the ammunition is conveyed to the respective guns, without being exposed to shell fire. The main and middle decks aft will be fitted for the use of the admiral and captain and their numerous staff. The whole of the remainder of the main deck and middle deck forward is devoted to the messing and sleeping quarters of the crew.

The total complement of officers and men will be

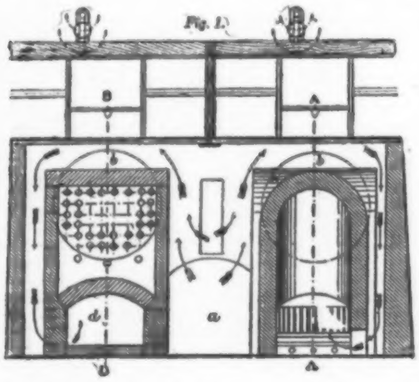
about 800 all told. The machinery space is divided by means of longitudinal and transverse bulkheads into six watertight compartments, two of which will be used for the engines and four for the boilers. The vessel has a large coal capacity, having space for 1,800 tons in side bunkers partly above and partly below the protective deck. The spaces below the protective deck at the ends of the ship are largely devoted to the stowage of ammunition and torpedoes, and contain also the steering gear, capstan engine, ventilating and air compressing engines, and the dynamos, all of which, being essential to the fighting efficiency of the ship, are necessarily kept below. The vessel is fitted with bilge keels, in order to reduce the rolling to a minimum. The engines of the vessel are of the vertical inverted triple expansion type. The collective horse power is estimated to be 12,000, which will give a speed of about 17½ knots on trial. The boilers, of which there are eight, are of the ordinary single ended return tube type.

MEGASS AND REFUSE FURNACES.*

By William Price Abell, Wh.Sc., Assoc. M. Inst. C.E.

The use of megass as fuel in the manufacture of cane sugar has, during the past few years, largely owing to the increased cost of coal, become more

Fig. 1.



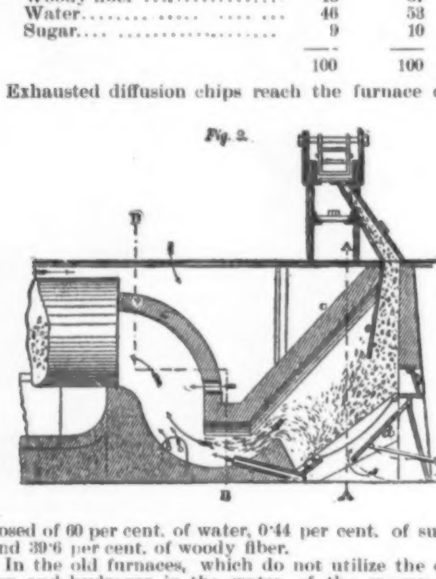
general; and on many estates in the West Indies it has entirely replaced coal, of which 25 cwt. were formerly required for the production of one ton of sugar. During the years 1890-94, 520 furnaces were rebuilt in British Guiana, at a cost of about £50,000, the annual saving thus effected amounting to more than £100,000.

On the assumption that sugar cane contains 12·5 per cent. of woody fiber and the juice 16 per cent. of sugar, Mr. Nevile Lubbock states as the result of many trials that double crushing extracts 72 per cent. and single crushing 66 per cent. of the juice, leaving the green megass composed in each case of woody fiber, water and sugar in the following proportions:

	Double crushed. Per cent.	Single crushed. Per cent.
Woody fiber	45	37
Water	46	53
Sugar	9	10
	100	100

Exhausted diffusion chips reach the furnace com-

Fig. 2.



posed of 60 per cent. of water, 0·44 per cent. of sugar, and 39·6 per cent. of woody fiber.

In the old furnaces, which do not utilize the oxygen and hydrogen in the water of the megass for combustion, it is calculated that 4·83 lb. of double crushed megass and 5·98 lb. of single crushed megass are required to give the same amount of available heat as 1 lb. of Scotch coal. Sir Frederick Bramwell and Dr. Letheby, in their report on the sugar manufactories belonging to the Khedive of Egypt, state that 2·09 lb. of sun dried megass are equivalent to 1 lb. of Welsh coal.† From 100 tons of single crushed cane are obtained 34 tons of megass, sugar and water combined as fuel, 8½ tons of sugar, and 57½ tons of water, to be evaporated out of the juice; and from 100 tons of double crushed cane there result 28 tons of megass, sugar and water as fuel, 9½ tons of sugar and 62½ tons of water to be evaporated out of the juice. With single crushing, therefore, for every ton of sugar manufactured, 4 tons of refuse or megass, of which 53 per cent. is water, and with double crushing 3 tons of megass, of which 46 per cent. is water, are obtained. This fuel, in modern though still imperfect furnaces, will evaporate 57½ tons to 62½ tons of water from the juice of 100 tons of cane, besides generating all the mechanical work involved in crushing the canes and manufacturing the sugar. A surplus of megass should be stored while the mills are working, so that it may be possible to manufacture with it the offal products after the grinding ceases.

The results of long grinding at a factory producing 1¼ ton of sugar per hour show that the amount of megass available per hour is 3·75 tons, consisting of 2·03 tons of fiber and 1·72 tons of water. This is burnt in five furnaces, of which two are of the type shown in Figs. 1 and 2 and three are of the type shown in Fig. 3, 4·24 cubic feet of megass being thus available for each furnace per minute; but sufficient steam is maintained with 3 cubic feet per minute. Each furnace has a grate area of 20 square feet, and each supplies heat to a multitubular boiler containing 1,300 square ft. of heating surface.

The chimney draught, as shown by a Bailey draught gage, is 40 ft. per second, the flue temperature, as shown by a Bailey pyrometer, is 500° F., and the furnace temperature is such as to melt copper and partially melt cast iron, about 2,000° F. The steam obtained from these five boilers and furnaces concentrates and purifies 9·45 tons of juice into 1¼ tons of pure yellow sugar per hour. The boiler pressure is 75 lb. per square inch, and the cane is crushed at the rate of 13·2 tons hourly, 3·75 tons of megass and 9·45 tons of juice being produced—the latter consisting of 1·25 tons of sugar and 8·20 tons of water and offal. In addition to extracting juice from the canes with a pressure of 250 tons on each of the top rolls, the water is evaporated, the sugar is cured and the molasses is converted into rum and second sugar. The 3·75 tons of megass develop the requisite power without the assistance of any other fuel, the duty of the engines employed amounting to 463 I. H. P., and the heating surface in the evaporators being 5,650 square ft.

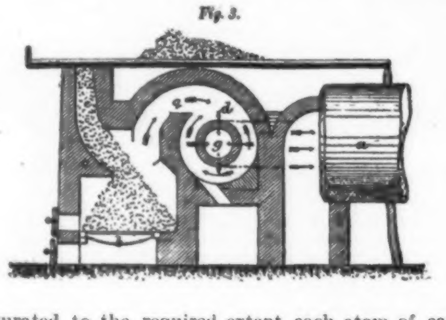
The water in megass was, until a few years ago, evaporated in the furnace and driven out of the chimney as waste steam. In some cases the megass was dried in the sun or in logies, on the theory that to employ water as fuel was to use more energy than could be realized from the combustion of the oxygen and hydrogen obtained from its decomposition. Ordinary megass, if burnt in the usual way, scarcely produces heat enough to promote its own combustion. The result of the improvements in furnaces has been that condensed steam or white smoke is seldom seen issuing from megass chimneys. Green megass may be taken to consist of 50 per cent. of fiber and 50 per cent. of free water, the small quantity of sugar and ash present being negligible. The chemical analysis of the substance is:

	Per cent.		Per cent.
Carbon	25·00	Woody fiber	50
Hydrogen	2·78		
Oxygen	22·22		
Hydrogen	5·56	Free water	50
Oxygen	44·44		

Megass thus contains exactly the amount of oxygen necessary for the complete combustion of its carbon.

When hydrogen and oxygen exist in a compound in the proper ratio to form water, its constituents have no effect on the total heat of combustion. This would be the case with woody fiber in megass, under ordinary circumstances, when burnt in the older type of furnace. On the other hand, in a properly designed green megass furnace, when thoroughly heated, the water, in the form of aqueous vapor, is decomposed in passing over the highly incandescent and porous carbon of the megass; oxygen is liberated, and combines with the carbon to form carbonic acid; and the hydrogen passes off partly uncombined and partly as carbureted hydrogen. The latter, in presence of sufficient oxygen and at the high temperature of the furnace, undergoes further combustion, and yields additional heat by its conversion into carbonic acid and water. This is shown in practice by the fact that little air is required for a furnace after it is properly started. If the pores of megass could be impregnated with air and

Fig. 3.



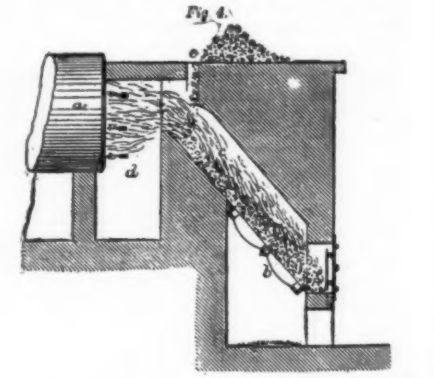
saturated to the required extent, each atom of carbon being contiguous to the necessary air before the fuel was thrown upon the grate, the result would differ from the ordinary smouldering combustion, and would approach that of gunpowder, which contains the necessary oxygen for perfect combustion without air. The fuel should first be gasified and then burnt, the moisture being split up, and the oxygen and hydrogen used for the combustion of the carbon in the megass

In an efficient megass furnace perfect combustion of the gases and carbon flecks should be produced, the gas being first liberated and then consumed, so that no white vapor escapes from the chimney. It should require no increase of chimney height, and should work without forced draught. The temperature in the combustion chamber should be sufficiently high for the production of water gas. Ample provision should be made for expansion through large and varying ranges of temperature. Furnaces have been constructed in which the waste heat from the chimney is utilized for drying the fuel on its way to the firebox. Experiments made by the author in 1887, however, showed that with a flue temperature of 550° Fah., a layer of megass 3 in. thick took forty-five minutes to dry.

In Fig. 4 is shown the Alfred Fryer furnace, introduced in 1883 by Mr. Maurice Costa, and adopted with success in British Guiana. The grate, b, is inclined with the lowest part at the furnace front, and the green megass is introduced between the bars and boilers, a, so that all the flames pass through and over the green fuel on its way down the drying plane, c. The megass is introduced at the opening, e, and, falling on the inclined drying plane, it gravitates downward on the fire bars as that below it is burnt. The whole of the products of combustion pass up over this drying plane, and there evaporate, taking up much of the moisture of the megass. The flames then pass the feed mouth into the combustion chamber, d, and finally into the boiler. No air was observed to be drawn in at the feed mouth, although the stream of flame was always plainly visible passing this opening, which measured 10 in. by 5 in.

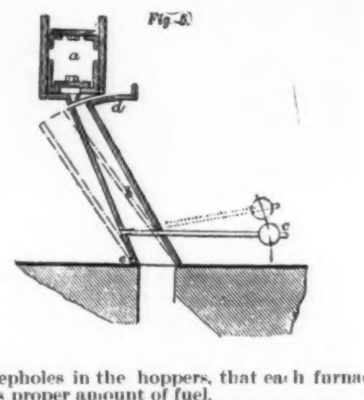
In 1890 the furnaces shown in Figs. 1 and 2 were introduced by the author. They are arranged in pairs, the air for combustion being drawn between the two furnaces at a, over the boiler tops, b, and finally over the reverberatory arches, c c', into the ashpit. The air is caused to pass the hottest or lower part of the fire bars by the deflecting plate, d, reaching the top end of the fire bars and entering the megass at a temperature of 300 deg. Fah. The check wall or plate, e, regulates the thickness of megass on the fire bars. In order to still further heat the air and facilitate the complete combustion of the gases and carbon flecks, a similar furnace, but possessing an additional combus-

Fig. 4.



tion chamber, was introduced and gave highly satisfactory results. In 1892 the automatic feeding arrangements were added, with a view to reduce labor on megass platforms, to dispense with the gearing hitherto used in mechanical firing, and to give a constant and regular feed of fuel. They have proved so sensitive in practice, that without any assistance they can supply one furnace with the exact quantity of megass, passing the surplus on to the next. The megass is carried the whole length of the platform by the usual rake carrier, connected with each furnace by inclosing hoppers. Down these the megass falls direct into the furnaces until the hopper is sufficiently full to cause the megass in the carrier to pass over that in the hopper. The surplus megass can either be discharged at the carrier end or be stored between each furnace by opening intermediate doors under the control of the attendant. No firemen are required, except when the megass furnaces are not stopped, owing to the mills ceasing work, in which case, by simply opening the door at the bottom of each inclosing hopper, the furnace can be fed by hand in the usual way. The attendant simply regulates the flue dampers to give the necessary steam, and adjusts the intermediate doors, to prevent too much megass from accumulating at one place. He also sees, by means

Fig. 5.



of the peepholes in the hoppers, that each furnace is taking its proper amount of fuel.

The apparatus shown in Fig. 5 utilizes the weight of the megass to regulate its own feed. The hopper is hinged at e, f being an opening in the cross carrier, d a damper or sluice, and c a balance weight. The megass passes down the shoot, b, to the furnace until it is full, and then the weight of the megass, accumulating in the hopper, causes it to descend about the hinge into the position shown by the dotted lines, at the same time raising the balance weight and sliding the sluice or plate over the opening, f, thus causing the megass to pass on to the next furnace.

In 1893 a furnace was tried by the author in which the fuel was passed through an open-ended retort projecting vertically into the combustion chamber. The flames of combustion heated this retort, and thereby heated, dried and distilled the gases out of the megass ready for combustion so soon as they reached the combustion chamber, the solid, partly dried fuel falling upon a hearth surrounded by four pigeonholed walls. It was found advantageous to block up the pigeonholes until only seven square feet of grate area were allowed for burning seven cubic feet of megass. The ratio was thus one square foot of grate area per cubic foot of megass, whereas it had previously been six square feet of grate area per cubic foot of megass burned per minute. In other words, with a boiler hav-

* Selected paper published in the Proceedings of the Inst. C.E., and reproduced by permission.

† See also Minutes of Proceedings Inst. C.E., vol. xlviii, page 87.

ing 1,300 square feet of heating surface, the furnace having one-third the usual grate area, the amount of steam obtained from double the quantity of megass was three times that derived from similar boilers with ordinary furnaces in the same battery, and this with a natural chimney draught of 40 feet per second. The construction of the furnaces required only about half the number of bricks of ordinary furnaces.

The loss of megass, and particularly of diffusion chips when charred and partly burnt, is considerable, on account of the unburnt carbon flecks. These are similar in appearance to the end of a charred match, and are carried through the furnace and up the chimney unburnt in such quantities that on a still morning the ground round a sugar factory becomes strewn with them to a depth of some inches. To prevent the waste from this cause, a centrifugal combustion chamber, Fig. 3, has been successfully adopted for retaining the carbon flecks until they are distilled and completely consumed. The megass enters at e, and falls to the fire bars, b. The flames are led into the combustion chamber, d, tangentially at g, so that the heavy unburnt particles are speedily separated from the light gases by centrifugal force—the heavy sparks and carbon flecks flying off to the circumference, and the light flames of combustion finding their way through the center, g, up the flue into the boiler, a. The same arrangement has been applied with success to the retort type of furnace, wherein the combustion or whirling chamber is arranged above the hearth, around which are fixed tangential tuyeres supplied with air, preferably under pressure, from the chamber. The air enters the tuyeres and produces a whirling motion, which causes the heavier unburnt particles of megass or chips to remain in the chamber, which is of large diameter, in virtue of their weight, while the lighter products of combustion pass up the deflector.

The economy of megass furnaces is still susceptible of great improvement, by the adjustment of the proportions in which the several constituents are consumed, rather than by the introduction of new principles of construction or operation.

AN ELECTRIC REFRIGERATING MACHINE.

THE production of cold by means of the machine represented herewith is based upon the use of anhydrous liquid ammonia, which, through its evaporation, absorbs the heat of the surrounding bodies. Although the apparatus may be employed for the manufacture of ice, it is more particularly designed for keeping apartments at a definite temperature for the sake of comfort.

The vaporizer or refrigeratory consists of a system of tubes in which the ammonia gas expands and circulates indefinitely, but in most cases the carriage of the cold is effected through the circulation in these pipes of an incongealable liquid cooled by a vaporizer or expander installed near the machine. A pump compresses the ammoniacal vapors, which liquefy in a condenser in which the cold water of circulation removes from the ammonia the heat absorbed during its passage in the vaporizer.

It is the well known principle upon which is based the operation of frigorific machines using gas liquefied by compression. The peculiarity of the installation that we represent consists in its being actuated by means of electric energy. The apparatus for producing cold is of the type devised by Mr. Linde, to whom is due in great part the credit of causing the ammonia gas machine to take the rank that it at present occupies in the industries.

As for the electrical part, that is due to the Allgemeine Elektricitäts Gesellschaft, of Berlin. According to circumstances, the transmission of motion to the frigorific machine or rather to the compression pump is effected by means of a belt, friction disks or an endless screw gearing. It is this latter method of actuating that is here figured.

The electric motor is established upon a bracket fixed to the ice machine and connected by means of coupling boxes with the shaft of the endless screw. The wheel is keyed directly upon the crank shaft of the compression pump, which is arranged vertically. A heavy flywheel makes the running uniform, and the endless screw, as well as the wheel at the point of gearing, is covered with guard plates.

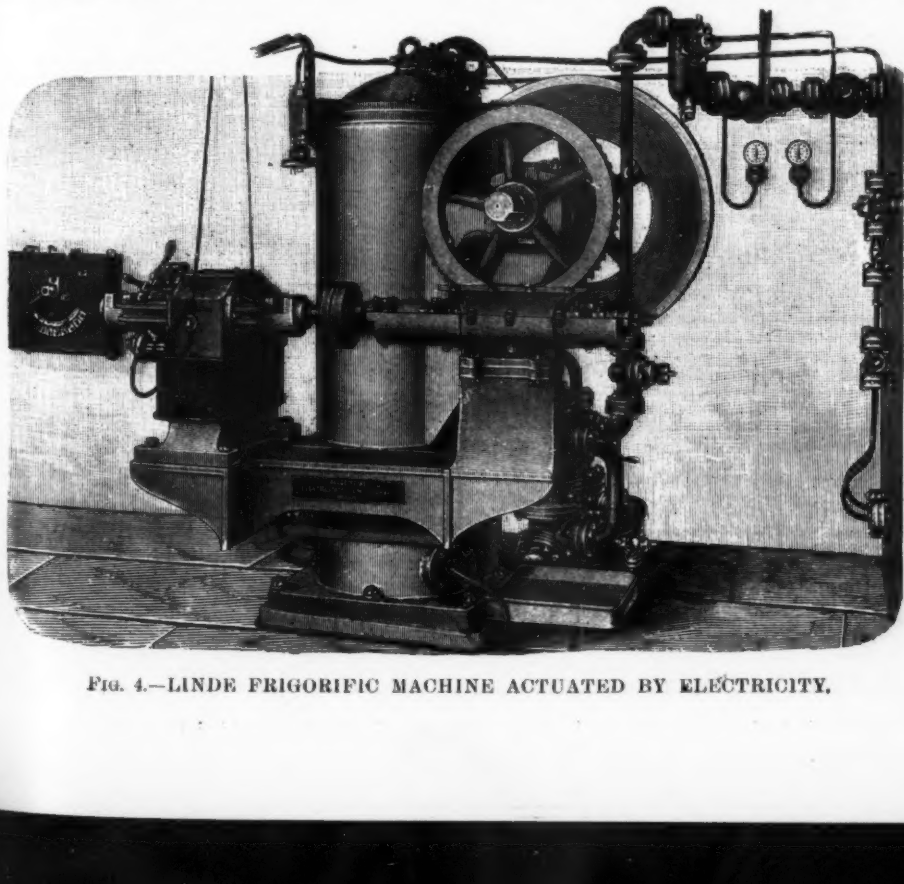
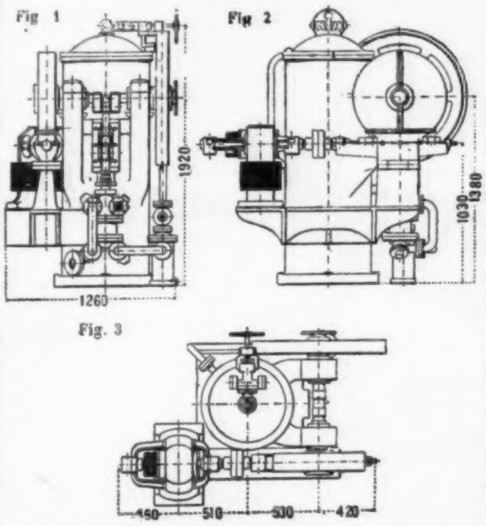


FIG. 4.—LINDE FRIGORIFIC MACHINE ACTUATED BY ELECTRICITY.

An installation of this kind is particularly recommendable for small establishments supplied by an electric system. It presents a great character of simplicity which reduces the surveillance in a great measure. Besides, no heat is developed for the production of the work, as in the use of machines employing fire, which, in this regard, may exert a certain influence upon the rendering.

Under certain working conditions, when the machine is provided with a circulating pump, it consumes about 3,660 watts, and, without a pump, about 3,200 watts.

Such electro-frigorific installations may find numerous applications by reason of their simplicity and the facility with which they may be employed; for example, for the preservation of meat and food in abattoirs, hotels, and on ships, for the preservation of milk, and for the manufacture of ice in the trade of the confectioner. They are also well adapted for cooling air, which, remaining always dry and pure, may be employed in hotels, villas and dwellings, especially in southern climes.—Revue Industrielle.



DETAILS OF FRIGORIFIC MACHINE.

SODIUM IN ALUMINUM.

AN important paper, having for its title "On the Presence of Sodium in Aluminum produced by Electrolysis," was read at the recent meeting of the Academie des Sciences, in Paris, by M. Moissan, of which the following is a brief extract.

The results, the author stated, obtained by many experimenters into the properties of aluminum have been of a very varied and often contradictory character. In several countries endeavors have been made to utilize aluminum on account of its lightness, in the form of culinary and other utensils, and so lighten the equipment of soldiers. Here, again, varying results have been obtained; in some cases the metal has been found to give such good results as to warrant its extended use, but in others it has proved deceptive. These difficulties are due principally to differences in the composition of aluminum as made for commercial purposes. In July, 1894, M. Moissan demonstrated that it is possible for aluminum to contain nitrogen and carbon, and he has shown that the presence of these bodies greatly modifies its properties. M. Moissan has recently had occasion to analyze samples of aluminum obtained from three of the largest existing aluminum works at La Praz, France, Neuhausen, Switzerland, and Pittsburg, U. S. A., and it is the result of these tests that he communicated in the paper under notice. The author stated that he found in the aluminum a new impurity, which appears to him to have an important effect on the conservation of the metal, the impurity in question consisting of sodium. The presence of this impurity in aluminum may be determined in the following manner: Place 250 grammes of filings, carefully prepared, in an aluminum bottle containing 300 cubic centimeters of distilled water, the latter to be prepared in a metallic still. This mixture, together with the bottle, is placed at one side for a couple of weeks; it, however, being caused to boil every day. The contents are then passed through a filter and washed in boiling water. The remaining liquid, which is slightly alkaline, is then evaporated to dryness in a platinum capsule. It is next heated up to a dark red, the mass becoming brown in color. Dilute pure hydrochloric acid is then added, when carbonic acid will be given off. The mass is again evaporated to dryness, then heated up to a temperature of about 300 deg. C., in order to drive off the excess of hydrochloric acid. When this is done there will be a residuum presenting all the characteristics of chloride of sodium. This is taken up by water and the quantity of chloride in the form of chloride of silver estimated. From the weight of this latter body the quantity of sodium taken up by the water from the aluminum filings may be deduced.

In the course of his experiment, M. Moissan has traced the presence of sodium in quite a number of samples of aluminum, the content varying from 0·1 to 0·3 per cent. An old sample of aluminum was found to contain 0·42 per cent. The presence of sodium in aluminum shows that the electrolytical action of a mixture of cryolite and alumina gives rise to a number of secondary reactions, in which sodium may play a variable part, according to the composition of the bath and the intensity of the electric current.

Coming now to the effects on the properties of aluminum when sodium is present, M. Moissan states that cold water will attack aluminum, at first slowly, followed by progressively increasing intensity. In fact, if a sheet of aluminum is surrounded by a small volume of water, it will be found that a thin layer of alumina will be formed on the metal. Allowing the metal and water to stand undisturbed for a short time, it will be seen, after a few days, that the liquid has an alkaline reaction on sensitive litmus paper. From that time forward the decomposition of the metal becomes very rapid. On every part of a piece of aluminum containing sodium alkali is to some extent formed, which reacts on the metal, giving an aluminate. This aluminate of sodium can afterward be separated by water, giving a sediment of alumina and soda.

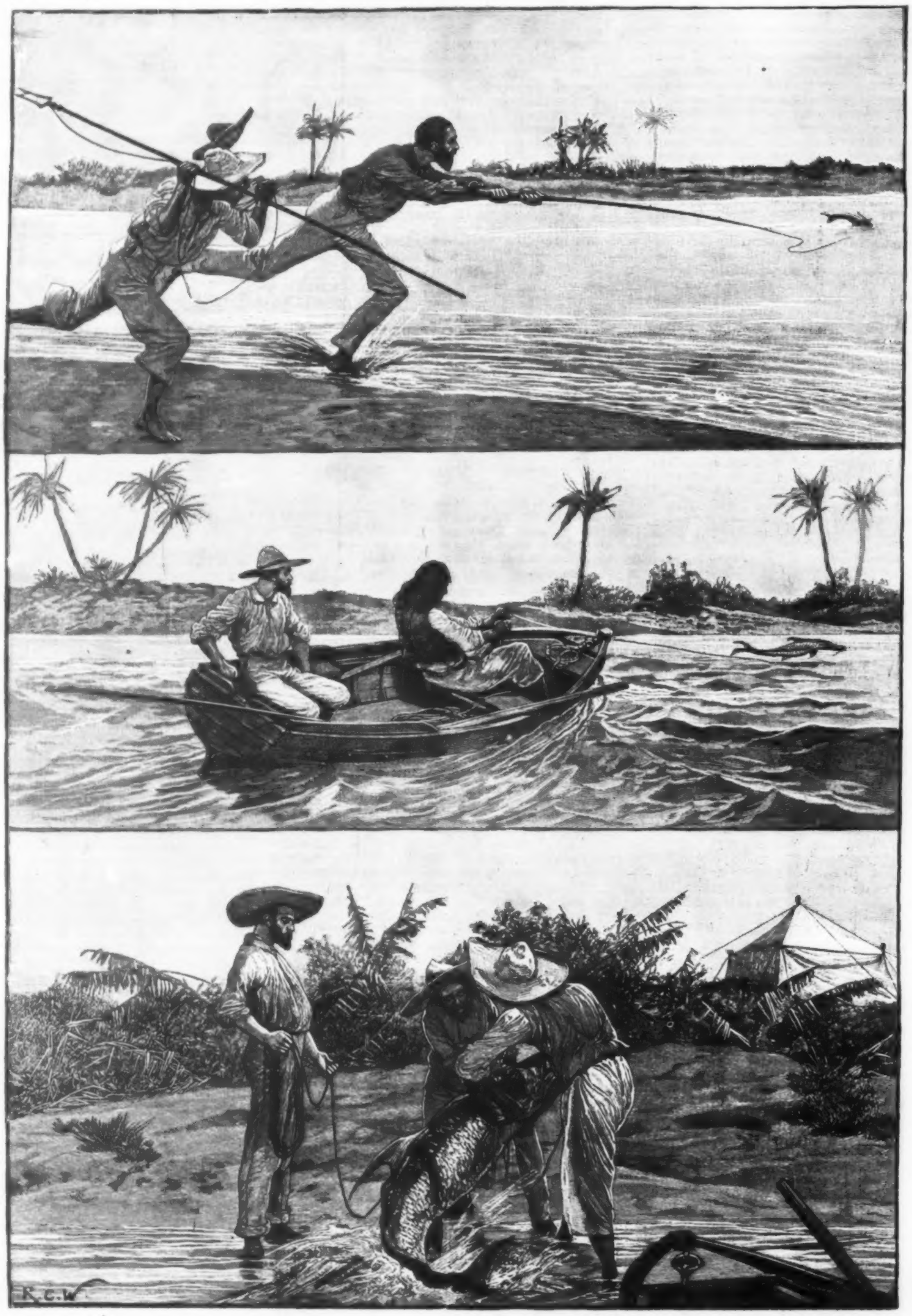
It will be apparent from the foregoing that the alloys which it is possible to prepare with aluminum will possess very different properties, according as the metal contains a slight percentage of sodium or not. In this connection it may be stated that M. Riche, in his work on alloys of tin and aluminum, has shown that these alloys decompose water at ordinary temperature. M. Moissan succeeded in preparing an alloy of 6 per cent. of tin with aluminum entirely free from sodium, and under these conditions, after being immersed in ordinary water for a period of two months, the metal became spotted at several points, and gave some efflorescences of alumina. No gaseous vapor was however given off. This experiment was carried out as follows: Aluminum, free from sodium, was alloyed with 6 per cent. of tin, while shielded from the action of nitrogen and the furnace gases. A sheet of this metal was divided into two parts. The first piece was placed in the river Seine, where the water is agitated each day; the second piece was placed in a Bohemian glass containing Seine water, on which was a layer of oil several centimeters thick. The average temperature in the laboratory was about 20 deg. C. The experiment, which was commenced in September last, was carried on over a period of two months. During this time the aluminum became covered with white efflorescences, it became spotted over nearly the whole of its surface, but in neither case were any globules of hydrogen given off. It was found that the piece of aluminum placed in the river was most rapidly attacked. This experiment was made on an aluminum containing only a small proportion of tin. M. Riche has, however, shown that with a greater percentage of tin the alloy more readily decomposes water, and it was upon this fact that M. Riche based his statement that aluminum could not be reliably welded by an alloy containing tin.

M. Moissan, before publishing the results of his experiments, communicated with several other experimenters in aluminum as to the presence of sodium, several of whom, including M. Riche, agree as to the presence of sodium. M. Moissan also drew attention to the lack of homogeneity in aluminum and aluminum alloys, especially an alloy of aluminum and copper. This want of homogeneity is especially noticeable in the many aluminum stampings now sold. Taking an aluminum vase and filling it with distilled water, at the end of a fortnight, a number of white spots of hydrate of alumina will be found on the vase. The spots continue to increase in size, and if the part attacked be cut out, and the hydrated alumina removed, a small particle of carbon or other substance will, in most cases, be discovered by the aid of a microscope, this forming a pole, causing the metal to be attacked on its surface in a more or less degree. By filling the vase with a saturated solution of chloride of sodium instead of water, the phenomenon becomes more noticeable, each particle of carbon causing a reaction on the sheet of non-homogeneous aluminum sufficient to penetrate it. On the other hand, in the case of homogeneous aluminum, having no trace of nitrogen, carbon, or sodium, no reaction takes place, and the water, although it may have been in contact with the aluminum for some time, will contain no alumina and will retain its limpidity. The same phenomenon is met with in the case of alcohol diluted with water, and in the case of a poor quality of aluminum this will explain the reaction which has been found to take place in aluminum drinking cups, and which has by some experimenters been attributed to the action of tannin.

In concluding his paper, M. Moissan remarked that "as aluminum has a great tendency to form an electric couple with any other metal, it should always be used alone, and not in conjunction with other metals. A piece of iron or brass in contact with aluminum will in a short time bring about the oxidation of the metal and its conversion into alumina."

TARPON FISHING IN FLORIDA.

THE accompanying engraving shows the method used in capturing the tarpon or, as he is called by anglers, the silver king. The fisherman uses a short rod and reel, the latter holding several hundred feet of line. The hook is attached to the line by either piano wire or a light chain, which is to prevent the fish from biting off the hook. All prepared, the sportsman and boatman anchor in water where the fish are in the habit of feeding. The bait used is a piece of mullet, which the tarpon is allowed to swallow before the angler drives the hook home. Then comes the struggle, as the steel becomes embedded in his throat or stomach, and in his agony he throws himself many feet in the air in his wild efforts to dislodge the hook. Failing in his endeavors, he starts off with a wild rush, towing the fishing skiff after him. The rushes and leaps continue till the fish is exhausted, when he is either landed by means of the gaff or pair of grains.—Ill. London News.



TARPON FISHING IN A FLORIDA RIVER.

ABOUT 15,000 tons of starch have been made from potatoes this season in the three States of Wisconsin, Minnesota and North Dakota. Not far from three and a half million bushels of potatoes have been thus used, and yet this represents about half the product of the potato belt. The farmers have received an average price of ten cents a bushel for the potatoes.

TECHNICAL EDUCATION.

By H. H. SIMMONS, A I.E.E.

THERE are two fundamental questions regarding technical education which are most difficult to answer, and are consequently most vexed. The one is, What should be the duration of the purely theoretical training? and the other, When should this training be given? To give an arbitrary answer to either of these questions is surely impossible, for it must be affected both by the natural capabilities of the individual and the course he has mentally mapped out for himself. Apart, however, from such variable considerations as these, there are, it seems, two sides to both questions—that is to say, it is an open question how best to give a good all-round training to a man of average capabilities.

The ideal method is an elastic combination of theory and practice, including manual training, and such that it leaves the learner free to attack any difficulty which presents itself in either direction, care being taken to maintain the balance, so that the bearing of practical on theoretical and theoretical on practical considerations be duly and simultaneously kept in view—an ideal almost impossible of attainment, except perhaps to the millionaire. This ideal is, however, hinted at, and an apologetic attempt to reach it is made in most technical colleges by the maintenance of a more or less sleepy workshop, where the machine tools are of an excellent kind, very much underworked and require little or no exercise of ingenuity or skill on the part of the operator. The expenditure on these shops is necessarily very large both in prime cost and upkeep, and it is hardly fair to look for improvements which would add largely to the cost of working.

It is, of course, out of the question to hope for manual skill of any high order from these shops, but they might surely be worked so as to be much more efficient in acquainting the students with ordinary workshop methods. Broadly speaking, one of three courses is now usually followed. College is made to follow immediately upon school, and the workshop or drawing office, or both, of some commercial undertaking, supplies the further practical training without which no budding engineer begins to be worth his salt. Or this order is reversed; or, thirdly, pupilage supplies the practical and evening classes the theoretical training.

The second course is, perhaps, the best, as a rule, for if a man be fit to become an engineer at all, he cannot fail to observe and to seek the why and wherefore of what he sees, and this renders him peculiarly receptive toward the information subsequently to be gained at a college.

There is, however, a fourth method which must commend itself to all practical men, and which is being more and more largely followed; it is also a nearer approach to the ideal. On leaving school the youth of 17 or so enters a workshop as a boy at from 4s. to 6s.

a week, and supplements this experience by evening study and technical training. In the workshop, workshop methods and current practice become familiar, while manual dexterity, not to be despised, though of very secondary importance, is also acquired; from private reading theory may, in these days of innumerable books on every subject, be slowly but surely learned, but only at the cost, it is true, of patient, laborious study. Technical training, an entirely distinct thing, as has often been pointed out, can only be gained by attendance at some technical institute, or by years and years of painful and costly experience. It is this training which is needed to enable the engineer to combine theory and practice and to truly estimate the relative importance of the considerations urged on either side for the solution of the problems he has to solve.

The advantage of this fourth course is that a widening range of acquaintance with both practical and theoretical considerations and their relative importance is acquired, and the risk of either preponderating unduly is reduced, but against this must be set off the extremely hard work entailed, which requires a tireless patience and perseverance in spite of the slow apparent progress made. We are living, however, in an age of hard work, particularly of hard mental work, and the man whose constitution, whose funds, whose patience and whose general education are sufficient, will find that this road will find him, broadly speaking, more competent, self-reliant and generally better fit to take a responsible post than his brethren who have chosen the other roads, but he may have to wait till he is between 30 and 35 before his advantage becomes apparent.—The Electrical Engineer, England.

SPANISH TROOPS IN CUBA.

WE give illustrations of the war worthy to satisfy the natural curiosity of our readers. It shows the entrance of the battalion of Tetuan in Havana, which arrived there recently on the steamer Santa Barbara. The march was through the street of O'Riely to the Castle of Principe, where they were quartered. The reception was most enthusiastic. The commercial employes in Obrapia Street presented to the soldiers 4,000 cigars.

FRESH TROOPS FROM SPAIN MARCHING THROUGH HAVANA.

It is announced that the Montreal Bridge Company has made arrangements with a New York syndicate to construct a bridge over the St. Lawrence River from Montreal to Longueuil at a cost of about $6,000,000.

THE NATURE OF CHEMICAL CHANGE AND THE CONDITIONS WHICH DETERMINE IT.*

FOREMOST among the problems to which during recent years attention has been devoted is that of the nature of chemical change. While English workers especially have made most important contributions to our knowledge of the conditions under which change will occur, foreign workers have been most active and successful in developing mathematical methods of treating the subject. Indeed, the statement recently made in a prominent chemical journal, that "It has certainly become impossible to read chemical theory without a working knowledge of the calculus," is a striking comment on the alterations in the conditions under which the chemist will work in the future, which must serve to remind us how very different a preparation students must now undergo if they desire to thoroughly master the theories of our science.

The subject first came under consideration in this society just ten years ago. In the discussion on Mr. Bereton Baker's paper on combustion in dried gases, I ventured to insist that the evidence that action did not take place between two substances was so strong that chemists would ere long be forced to form a definite conception of the nature of chemical action, and of the conditions under which chemical action could take place; and I then pointed out that physicists were in advance of chemists, drawing attention to Ayrton and Perry's paper on the contact theory of voltaic action, in which it is directly stated that Ohm's well-known law is equally applicable to electrical and chemical changes.†

On the occasion in question I defined chemical action as reversed electrolysis, and explicitly stated that in any case in which chemical action is to take place it is essential that the system of operation shall contain a material of the nature of an electrolyte. The expression "chemical action" was used as including all cases of exothermic change, cases of endothermic change being obviously comparable with direct electrolysis, as in all such cases energy from without must be impressed on the system.

Later in the year, at the British Association meeting at Aberdeen, in my address to the chemical section, I discussed the matter more fully, and then stated in so many words that the conditions which obtain in any voltaic element are those which must be fulfilled in every case of chemical action. I carefully pointed out, however, that there was nothing new in this, and, to justify my assertion, drew attention to various passages in Faraday's "Experimental Researches in Electricity," in which such a doctrine is laid down in the clearest possible terms.* Let me here again say that nothing is to me more surprising than the continued disregard of Faraday's teaching on this subject. We know that in regard to purely electrical questions, even in this country, it was not until Clerk Maxwell came forward as his interpreter that attention became riveted upon his conceptions; and abroad, even Clerk Maxwell was disregarded until Hertz's experimental demonstration insured that respect being paid to his pleadings which they were so long denied. Faraday's views regarding chemical action have never yet received proper notice, although the language in which they are expressed is so simple and direct that they cannot be misunderstood, and their completeness is surprising.

But one conception has been added to Faraday's teaching—that of "electrolytic or ionic dissociation or ionization." Although introduced by Clausius in 1857, it lay dormant until it was reintroduced and applied by Arrhenius in 1884, who gave to the hypothesis a quantitative form; but it did not become popular until 1887, when Van't Hoff introduced the conception of osmotic pressure. The successful application of the hypothesis in explanation of the abnormally high results obtained in the case of conducting solutions at once secured for it a very large measure of support. Whatever view may ultimately be taken of the hypothesis—whether it be retained as a permanent addition to our theories or not—its introduction has been eminently fruitful of results, and an already too voluminous literature of the subject has grown up with surprising rapidity. Yet it appears to me that it has been accepted by a particular school—at the head of which stands Ostwald, and who regard and treat all unbelievers as heretics worthy of the stake—not as a mere working hypothesis, but as an absolute creed, without any sufficient attempt having been made to discuss its general probability. And the application of Avogadro's axiom to solutions, however successful, as affording a mathematical method of discussing results, in principle involves the complete disregard of the essential difference between the liquid and gaseous states and of the fact that in liquids the molecules are subject to a control which they mutually exercise and which distinguishes the liquid from the gaseous state. Also it must not be forgotten that the arguments made use of apply almost entirely only to weak solutions—to solutions to which a law of simple proportionality may be expected to apply; that, in fact, the region explored is one in which the rate of change is represented practically by a straight line. Lastly, it is applicable only to electrolytes. Personally, I am still entirely unconvinced of the validity of the hypothesis, although no one can be more willing to admit that, in so far as weak solutions are concerned, a "law" has been discovered which is broadly true in mathematical form, however open to question the fundamental premises may be on which it is based. I am satisfied also that the phenomena of chemical changes are, as a rule, far more complex in character than is assumed by the advocate of the hypothesis.

If electrolysis, and, therefore, electrolytic conduction, be—as I contend and have long contended—conditioned by a conjoint influence exercised by the solvent, A, and the dissolved substance, B, there is, I imagine, no reason why other phenomena in which the conjoint influence of A and B comes into account should not be expressible in mathematically similar ways. In extenuation of such heresy I can only quote Clerk Maxwell's argument that if in a battery a septum be used which diminished the diffusion, it is probable it will increase in exactly the same ratio the resistance of the element, because electrolytic conduction is a process the mathematical laws of which have the same form as those of diffusion, and whatever interferes with one must interfere equally with the other, the only difference being that diffusion is always going on while the current flows only when the battery is in action.

It has always appeared to me that the chief objection to be urged against the ionic dissociation hypothesis is the fact that, of the very large number of compounds known to us, extraordinarily few are electrolytes—not even metallic chlorides generally are conductors, but only a very limited number; and it is particularly remarkable that while such inactive substances as lead and silver chlorides, when fused, are among the best conductors known, aluminum chloride—one of the most active compounds with which we are acquainted—is apparently not an electrolyte. Electrolytes are clearly a very limited class, and if we consider the general properties of compounds which conduct more or less readily, whether alone or in solution, and contrast them with compounds which are practically dielectrics, it is impossible to discover any good reason why "ionic disruption" should take place in the case of the one set and not in that of the other. And if, confining our attention to acids, we contrast those which in solution are apparently good conductors with those that are bad conductors, there is again no satisfactory "motive" for so considerable a difference discoverable; for example, taking sulphuric and acetic acid, why should the former suffer ionic dissociation so readily and to so considerable an extent and the latter to so slight an extent? I imagine that it is fair for the purpose to regard the acids as modified water, and to assume that the slight tendency of water to undergo ionic dissociation—of which more later on—is enhanced by the association of the water with the oxygenated group, and that whereas sulphuric anhydride has a marked effect, acetic anhydride has a very slight one. Yet this is hardly satisfactory, and would probably involve the conclusion that sulphuric acid should diminish in conductivity as the temperature is raised, as it then dissociates into anhydride and water;

* Address by Dr. Armstrong, president, to the Chemical Society, England.—From Industries and Iron.

† Hitherto chemists have only employed the two ideas of chemical affinity and the amount of chemical action, but we have shown that these ideas are simplified when regarded as electromotive force of contact and currents of electricity. To connect the two ideas we have a third, viz., resistance, and the electrical law of Ohm becomes the chemical law; the quantity of chemical action in unit times equals the sum of a great number of terms, each of which is an electromotive force divided by a resistance. (Ayrton and Perry, Proc. Roy. Soc., 1887, 27, 237.)

* Series VII, §§ 850, 858, 859; VIII, §§ 869, 918.

the very different behavior of sulphuric and acetic acids when vaporized, the former, but not the latter, undergoing dissociation, may be regarded as an indication that a similar change does not take place in the case of acetic acid, and, therefore, it might be supposed that acetic acid would undergo ionic dissociation to a far greater extent than is assumed to be the case as a consequence of the anhydride retaining its influence.

It may possibly be contended, as it has been in the case of water, that compounds generally are conductors to a very slight extent; but as all bad conductors seem to become worse conductors as they are more carefully purified, the burden of proof rests upon those who make such an assertion; and it is not in accord with the fact that very many such compounds are as active as compounds which conduct well, and which are therefore, by hypothesis, more or less fully dissociated. For example, acid chlorides generally act on alcohols generally with very considerable readiness under conditions under which the hal-hydrides produce but a slight effect.

With regard to water itself, to argue, as Arrhenius, Ostwald and others have done, from the hydrolytic action of water on the salts of weak acids and bases, that water to a certain but very small extent contains ions, that is, H and OH, is but to beg the question entirely, and a clear case of reasoning in a circle.

The recent redetermination of the electrical conductivity of water by F. Kohlrausch and Heidweiller gives the value $0{\cdot}04 \,.\, 10^{-10}$ at 18°, instead of $0{\cdot}25 \,.\, 10^{-10}$ previously arrived at by F. Kohlrausch. These authors have deduced from their results a value for the conductivity of pure water, viz., $10^{10} \,.\, \kappa = -0{\cdot}0361$. They calculate that if this conductivity be due to the presence of water ions, a cubic meter of water at 18° would contain 0·08 milligramme of dissociated hydrogen ions; and point out that if present only in this excessively minute proportion there would still be milliards of atoms of hydrogen per cubic millimeter, and neighboring atoms would be separated by distances of the order of light waves in dimension. These conclusions, however, are based on the acceptance of the view put forward by Arrhenius, that the dissociated ions alone conduct the current—from my point of view, therefore, it is a case of deducing one unknown with the aid of another unknown—of proving one assumption by another assumption, which is admittedly an unsatisfactory proceeding. I venture to think that it is still open to question whether pure water, indeed, whether any pure substance outside a very limited number, perhaps, such as the silver haloids, etc., be an electrolyte. Minute in the highest degree as the amount of impurity in the water examined by Kohlrausch and Heidweiller must have been, yet even this may have exercised a very considerable effect, and in fact there is clear evidence in the paper that an extremely minute amount of impurity does so act. Moreover, the difference between the lowest observed value and the corrected value appears disproportionately small when the reduction of the value previously obtained by Kohlrausch, effected by the removal of what after all must have been a very minute amount of impurity, is considered. The point is one of the utmost importance, and cannot be lightly brushed aside.

The methods made use of in calculating the amount of ionic dissociation of water are apparently all open to the criticism that they are based on eminently hypothetical premises, and it is particularly open to question whether the phenomena from which fundamental values have been deduced have received the proper interpretation. For example, the origin of the E.M.F. developed in liquid couples such as have been studied by Worm Müller, and much later by Nernst, and of the concentration currents of Von Helmholtz, is by no means clear. Nernst assumes that in such cases forces acting at the electrode surfaces are entirely eliminated, but, if so, it is not clear why any more than when an acid neutralizes an alkali an E.M.F. should be developed, for I imagine that in all such cases the changes take place within closed circuits. In fine, I am inclined to doubt whether polarization effects can be regarded as eliminated; the inquiry must be included with that into the existence of a true contact difference of potential independent of chemical change. The values deduced by Ostwald are based on the study of couples of the form: platinum-hydrogen | acid | alkali | hydrogen-platinum, and it is assumed that the E.M.F. developed is due to the formation at the one electrode of water from the hydrogen and the OH ions in the liquid, and at the other of hydrogen from hydrogen ions in the liquid, and the hydrogen of the electrode. Unfortunately, the description promised of the experiments has not yet been given, and it is therefore difficult to criticise them; it is not impossible, however, that the real cause of the E.M.F. was dissolved oxygen.

Pure liquids do not conduct, according to Kohlrausch, because (as Ostwald has put it, Brit. Assoc. Report, 1890, 335) their molecules have no space within which to resolve themselves into ions, and it is therefore not improbable that water would conduct electrolytically; and I presume that Ostwald meant even to imply that it would be a good conductor, as he immediately afterward spoke of water, too, containing ions to a certain but very small extent—if we could find a suitable solvent for it. But we never have found a suitable solvent, unless it be hydrogen chloride. The fact that single substances, such as the silver haloids, when liquefied, readily conduct, would appear in itself to be a sufficient argument in controversion of Kohlrausch's explanation of the influence of the solvent. Moreover, it is to be supposed that any liquid capable of acting as a solvent should condition electrolysis if the function of the solvent be but to act as a screen.

As a matter of fact, there is good reason to think that among liquids water is the only effective solvent that we can use.

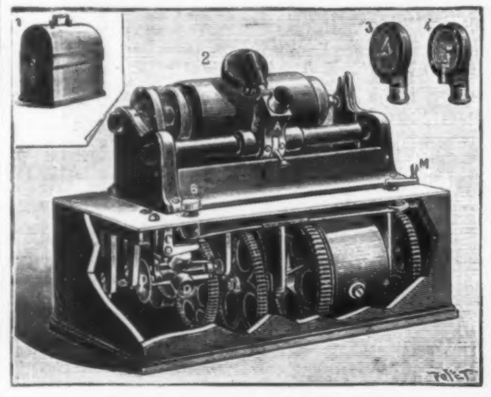
Alcoholic and some other solutions, it is true, conduct more or less well, but it is by no means improbable that when every precaution is taken to deal with highly purified materials, and especially to dehydrate the alcohol as fully as possible, such solutions will be found to be practically destitute of conducting power. This is the more likely now that Perkin has established the incorrectness of the supposition that until recently has always been made that hydrogen chloride, when dissolved in alcohol, acts fairly readily on it (Trans., 1894, 23). The observations made by Coleridge showing that solutions of hydrogen chloride in stannic chloride are but slightly conductive are also significant (Phil. Mag., 1890, 29, 303).*

If it be assumed that even pure water is to some slight extent dissociated; it is, at least, probable that liquid hydrogen chloride would contain some small proportion of ions prior to admixture with water; and, in point of fact, it is impossible to urge any reason why the one compound should be regarded as more dissociated than the other in the pure state. Yet the "ionists" not only assert that when hydrogen chloride dissolves in water it becomes almost completely separated into its ions, but make the arbitrary assumption that practically it alone is dissociated, the extent to which the water is dissociated being, indeed, diminished by its admixture with hydrogen chloride according to their view. This question is of fundamental importance as bearing on the validity of the argument on which Ostwald and others have sought to base a method of determining the heat of formation of water from its ions and on the interpretation they have given of the changes attending the neutralization of acids by alkalies.

A PORTABLE PHONOGRAPH.

MR. WERNER has just devised a new style of phonograph that seems to us to possess qualities that render it thoroughly practical and within the reach of all. The different apparatus hitherto described in these pages have given excellent results, but have not realized as well as the one under consideration all the desiderata that we have a right to expect from a family apparatus. The principal parts of the "loud speaker" do not differ essentially from those of the primitive phonograph. We find therein the wax cylinder of the same form as that of the usual Edison model; parallel with this a carriage, A, to which is added the registering disk or the speaking one and the cornet for allowing speech or song to be heard by a room full of people, or, if preferred, a thin tube of rubber for individual listening.

In Figs. 3 and 4 are shown the two principal parts, the register and the transmitter, which have been greatly improved since the Edison invention of 1878. The essential part in both is a disk of mica closing a small ebonite box surmounted by a tube of the same material, which is adjusted to the carriage, A. The latter carries a bent tube and the various parts for the registering or reproduction of the sounds. When it is



THE WERNER PHONOGRAPH.

1. The portable apparatus with its cover. 2. General view and internal details of the apparatus. 3. Registering disk. 4. Disk for the reproduction of speech.

desired to inscribe speech or a song upon the cylinder, a mica disk carrying a small knife (3) is used. The cylinder is set in motion by ungearing the clockwork movement, and one places at an inch or so from the mouth a small cornet fixed to the extremity of a flexible tube, whose other end is adjusted to the free part of the carriage.

When it is afterward desired to reproduce what has thus been registered, the other disk (4) is substituted for the first. It will be remarked that this differs entirely from the other, in that the small blunt point that rests upon the cylinder is not in the center of the vibrating disk, but at the side, and is connected with the center through a lever. These arrangements have been especially studied, and it is to them that is due the purity of the articulation and the intensity of the sound that the apparatus under consideration gives. The result is such that, even without the addition of any accessory, what the apparatus says may be understood at a distance. The clockwork contributes in a large measure toward rendering the apparatus practical. It is so constructed as to be entirely hidden in the base of the apparatus, the dimensions of which are 10 by 6 by 5 inches. The regulating part, although not absolutely new, is very interesting. It consists of a ball governor, D, which causes a disk, P, to approach or recede according to the velocity of a stop, I, forming a brake. The position of this stop is regulatable at will by means of a lever, C, which is acted upon by a screw, B. The starting or stopping of the motion is effected by means of the handle, M, which, through a flexible rod, acts directly upon the lever.

It is therefore very easy to vary the velocity of the registering cylinder, and nothing is more curious than to make it rapidly repeat what has been slowly pronounced. When, especially, one listens to his own voice, the effect is exceedingly surprising.—La Nature.

CAMPHOR MAKING IN FORMOSA.

THE Rev. George Ede, of the English Presbyterian Mission in Formosa, gives the following account of the process for recovering camphor adopted by the Chinese distillers in the island: "A fireplace is built and a shallow iron vessel (the kind used in Formosa for boiling rice) inserted therein. The walls of the fireplace are carried up a short distance and a meshed frame placed across the opening. A large earthenware vessel is then placed inverted over the top. It is made to fit more or less closely to prevent (as far as is safe) the escape of vapor. The pieces of wood are chipped off from the tree with an adz diagonally to the grain. Each piece of wood is then beaten till it splits more or less up along the grain. This is to expose the surfaces where the camphor lies. Some of the pieces of wood are about the size of one's hand, or less. The slices are not very thick. Water—not too much—is put into the iron vessel. The prepared pieces of wood are placed on the top of the meshed frame. A wood or charcoal fire is lighted under the iron vessel. It must be a slow fire and the water must not boil violently." The method, though cumbersome and uneconomical, has been followed for generations, and will probably continue to be resorted to so long as there is a camphor tree left in the island.—The Chemist and Druggist.

* These observations require to be repeated, taking every possible precaution to exclude moisture.

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